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PART I
Case Studies and Experience Papers

Effective Implementation, Meaningful Use and Sustainability of Digital Health Interventions: The Role of Health Informatics and Imaging Informatics in Africa

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Table of Contents

Journal of Health Informatics in Africa

Editorial to the HELINA 2023 Proceedings

Nicky Mostert

Nelson Mandela University, Gqeberha, South Africa

The 2023 edition of the HELINA (HEaLthINformaticsinAfrica) conference was held from 01 – 03 November 2023 as an in-person conference in Cape Town, South Africa. The conference was hosted by the South African Health Informatics Association (SAHIA) in partnership with HELINA. The conference theme was focused on "Effective Implementation, Meaningful Use and Sustainability of Digital Health Interventions: The Role of Health Informatics and Imaging Informatics in Africa". The aim was to provide a platform to showcase interventions in the following formats:

- Full research papers based on mature research results;
- Work in progress papers based on work in process research; and
- Case study presentations based on case studies and experience in digital health interventions.

Review Process

A total of 61 submissions in these categories were received. A double-blind peer review process was used for evaluating each full research and work in progress paper. These submissions were anonymized before being submitted to reviewers according to their area of expertise. The Scientific Programme Committee (SPC) based their final decision on the acceptance of each full research and work in progress paper on the recommendations and comments from reviewers. Accepted submissions were then sent back to the authors for revision according to the reviewers' comments. Case study submissions were reviewed by the SPC for inclusion in the conference. This review process resulted in the following acceptance rates:

- Full research papers: 44% acceptance rate (9 received, 4 accepted)
- Work in progress papers: 66% acceptance rate (6 received, 4 accepted)
- Case studies and experience papers: 85% acceptance rate (46 received, 39 accepted)

In order to be included in the conference proceedings, authors had to submit their final camera-ready papers after incorporating reviewer comments, and accepted papers had to be presented at the conference in person.

Nicky Mostert
HELINA 2023 SPC Chair
January 24

Journal of Health Informatics in Africa

Domestication of E-Health Policies: A case study of the IGAD Health Data Sharing and Protection Policy

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Introduction: The paper examines the domestication process of the IGAD Regional Health Data Sharing and Protection Policy Framework. The purpose of the paper is to provide insights into the challenges, successes, and lessons learned during the domestication process of the policy framework.
Methods: The study used a qualitative research approach, collecting data through document analysis and semi-structured interviews with key stakeholders involved in the process.
Results: The case study revealed that each of the seven IGAD member states had a unique context, affecting key components of the domestication process. The study found that different countries were at different capacity and readiness levels, requiring country-specific roadmaps to ensure each country moves at its own pace. The paper also highlights the approaches taken towards aligning the regional policy with existing national policies and regulations and the use of national and subnational structures to implement the policy for operational efficiencies.
Conclusions: The paper provides valuable insights into the domestication process of regional data sharing and protection policies. The findings suggest that policymakers need to take into account country-specific contexts and readiness levels when domesticating regional policies to ensure effective implementation.

Keywords: Health Data, Data Sharing, Data Protection, Policy Framework, Domestication Process.

1 Introduction

The current age of pervasive digital usage has seen an upsurge in data that circulates in various mainstream and social platforms. However, much of this data is not always timely, accurate, or holistic, all of which undermine its usage in decision-making. This is especially so in health data matters, which have become increasingly pertinent in the wake of the recent Covid-19 pandemic, among other public health challenges. And yet, credible and timely health data is an essential component of health service delivery [1], because accurate interpretation of such data significantly shapes healthcare policies, strategies, and practice. This is especially so when health data sits at the intersection of technology, region, and politics. For example, the use of informatics technologies is spreading extensively in the healthcare sector. Such technologies provide new opportunities to improve patient care, enhance research, and enable innovative approaches to health service delivery [2]. But the success of such technologies requires the back-up of policies and regulations to safeguard patient privacy, data protection, and ethical considerations [3] – all of which are core considerations in medical-legal practices for their role in upholding human autonomy and dignity.

Indeed, there has been growing concern over the potential risks associated with the use of informatics technologies in the healthcare sector, including the unauthorized access, misuse, and mishandling of personal health data [4]. To address these risks, therefore, there is need for policy interventions to ensure that the benefits of informatics technologies do not undermine individual rights to privacy and confidentiality, among other rights. Some of the policies are formulated and implemented by individual states in partnership with ideologically aligned non-state actors, while others are the work of Regional Economic Communities (RECs), especially in circumstances where the need for cross-border disease surveillance is compromised by weak intra-state infrastructural and capacity challenges [5].

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A notable example is the Inter-Governmental Authority on Development (IGAD) policy on health data sharing in the IGAD region is based on the understanding that the free flow of health data across borders is essential for the delivery of effective healthcare services. The IGAD Regional Health Data Sharing and Protection Policy Framework [6] aims to boost health data sharing by ensuring the free flow of health data across borders, while safeguarding the protection of individuals' data and privacy. Within the policy is also the recognition of the need for adequate safeguards to ensure the protection of individuals' data and privacy. Hence, the policy balances between the competing interests of various stakeholders with the need to minimise the risks associated with data processing and sharing, which risks may lead to violation of privacy through abuse of digital communication tools [7].

Against this background, the current paper seeks to examine the domestication process of the IGAD Regional Data Sharing and Protection Policy Framework and provide insights into the challenges, successes, and lessons learned during the process.

As of now, a roadmap is being developed for the domestication process, which will be followed by the actual domestication of the policy within each of the seven IGAD member states of Kenya, Uganda, Sudan, South Sudan, Ethiopia, Somalia, and Djibouti. The paper, which used the case study methods, shall highlight the approaches taken by IGAD, GIZ, and the consultants towards aligning the regional policy with existing national policies and regulations, and the use of national and subnational structures to implement the policy for operational efficiencies.

Adopting the case study allowed the paper to draw lessons that could be beneficial to future regional bodies or countries with similar aspirations towards harmonizing data sharing and data protection policies. Overall, the paper examines the domestication process of the policy framework and provides insights into the challenges, successes, and lessons learned during the process.

2 Materials and Methods

A qualitative research approach was employed to investigate the process of domesticating the IGAD Regional Health Data Sharing and Protection Policy Framework. The data collection methods used were document analysis and semi-structured interviews with key stakeholders involved in the domestication process, including representatives from IGAD, GIZ, and consultants.

Research for the paper also involved reviewing relevant policy documents, reports, and meeting minutes related to the development and domestication of the policy framework. Document analysis was important in providing an overview of the policy framework, its objectives, and the steps taken towards its domestication.

The paper also used semi-structured interviews with key informants, including policymakers, government officials, and representatives from civil society organizations involved in the domestication process. The interviews were conducted in person or via online platforms, and all participants were informed of the research objectives and their right to anonymity and confidentiality. The interviews were designed to gather information on the challenges, successes, and lessons learned during the domestication process. Questions were open-ended to allow for a detailed exploration of the issues related to the domestication process, including the alignment of national policies and laws with the regional policy framework, the utilization of existing structures for the implementation of the policy, and the format and procedure for information exchange between controllers and processors across member countries.

The data collected was analyzed thematically, and the findings were triangulated with the document analysis to provide a comprehensive understanding of the domestication process. But like other research, the current one faced some limitations, including overreliance on key informants perspectives and the limited number of countries included in the study. However, efforts were made to ensure the credibility and transferability of the findings by including multiple stakeholders from different countries and utilizing rigorous data analysis techniques.

3 Results

The case study revealed that each of the seven IGD member-states had a unique context, which affected key components of the domestication process. As a result, different countries were found to be at different capacity and readiness levels. This necessitated development of country-specific roadmaps to ensure each country moves at its own pace and receives the necessary support to achieve the objectives of the policy.

Desktop reviews were a challenge for some countries as the information was not updated publicly and was often fragmented across various offices. In Djibouti, a language barrier challenge was observed, which often required a translator to facilitate the information exchange process. It is important to consider the various challenges that may arise in different countries given their respective contexts.

To ensure that IGAD member states make progress in implementing the Regional Health Data Sharing and Protection Policy Framework, the policy requires member states to form implementation teams that comprise representatives drawn from the respective ministries of health at national and subnational levels, other public sector agencies engaged in data governance, including national data protection authorities, and ministries in charge of information, communication and technology. Other representatives shall be drawn from the private sector, national health information departments and health care managers, a representative of IGAD, civil society groups, and the academia.

IGAD requires that for each member state, the implementation committees shall plan to implement the policy at three stages. These are:

i) The Planning Stage: Here, a detailed road-map is worked out, where specific issues and gaps within member-states are identified, issues analyzed, and lastly the envisaged solutions are identified and prioritized;
ii) The operationalization stage where the policy is rolled out as per the road-map. This should entail putting in practice the solutions identified in the planning stage; and,
iii) The performance monitoring stage where implementation progress is tracked and reviewed on a milestone basis. This should ideally entail continuous practical monitoring, evaluation and communication to stakeholders.

To ensure that IGAD member states move to achieve the same goal in implementing the Regional Health Data Sharing and Protection Policy Framework, the policy document also provides key success metrics that become targets.

Despite the uneven progress made by member states in terms of boosting data credibility and sharing avenues, it is noteworthy that the project was viewed positively by all stakeholders. Some of the authors struggled with perceived levels of high optimism in the objectives of the project and the envisioned end goals. The policy advocacy component was well executed. Each country had a National Policy facilitator who played an instrumental role in linking the various in-country stakeholders with those outside, such as consultants. Their role was fundamental in achieving and ensuring the objectives of the project were being met.

The provisional findings suggest, in summary, that a one-size-fits-all approach to the domestication process is not feasible, especially given the unique contexts and challenges of each country. A country-specific roadmap is necessary to ensure successful implementation of the policy. Additionally, the availability of information and language barriers can pose significant challenges that must be addressed. Finally, the role of National Policy facilitators was critical in achieving the project's objectives.

4 Discussion

Our provisional results show several important insights regarding the implementation of the IGAD Health Data Sharing Policy.

Firstly, countries are at different stages of readiness and capacity to implement the policy. This suggests that each country will require a tailored approach to the implementation process, taking into account their unique context and needs. Furthermore, some countries may require more support to achieve the policy objectives, highlighting the importance of providing adequate resources and technical assistance to facilitate implementation.

The study also identified various challenges faced by countries during the implementation of the greening process. First, not all IGAD member states had equal and timely access to health information. Second, information availability varies across countries, with some countries facing difficulties in accessing updated and comprehensive information required for desktop reviews. Third, language barriers were a big challenge in countries such as Djibouti, requiring the use of translators to facilitate the information exchange process. All these challenges highlight the importance of contextual factors when developing implementation strategies for the policy.

Despite these challenges however, the study established that stakeholders viewed the policy positively and expressed optimism regarding its objectives and end goals. This suggests that IGAD's policy advocacy efforts were effective in creating awareness and garnering support for the policy.

The study also identified the crucial role played by national policy facilitators in linking stakeholders within and outside countries. These facilitators were instrumental in ensuring that the policy objectives were met and that stakeholders could collaborate effectively towards implementation. This finding highlights the importance of having effective governance structures in place to facilitate policy implementation.

Noteworthy, the study findings suggest that the implementation of the IGAD Health Data Sharing Policy, which will require a tailored approach that takes considers the unique needs and contexts of each country. Addressing challenges related to information availability and language barriers will be important in facilitating implementation. Ultimately, the positive attitudes expressed by stakeholders towards the policy objectives and the crucial role of National Policy facilitators highlight the importance of effective policy advocacy and governance structures to facilitate successful policy implementation.

5 Conclusions

This paper highlights the importance of informatics technologies in the healthcare sector and the need to balance the benefits of data sharing with individual rights, including the right to privacy and confidentiality. The case study revealed that a country-specific roadmap is necessary to ensure successful implementation of the policy, given the unique contexts and challenges of each country. Additionally, the availability of information and language barriers can pose significant challenges that must be addressed. Finally, the role of National Policy facilitators was critical in achieving the project's objectives.

The study recommends providing adequate resources and technical assistance to facilitate implementation, addressing challenges such as language barriers and fragmented information, and tailoring the implementation process to each country's unique context and needs. These recommendations are expected to guide future regional bodies or countries with similar aspirations towards harmonizing data sharing and data protection policies.

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Journal of Health Informatics in Africa

Working with users to address data quality issues: Findings from user research in the development of the Data Observation Toolkit

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Background and Purpose: Data collected by community health workers (CHWs) are generally considered of poor quality and incapable of supporting decision-making. For CHW-collected data to be put-to-use, it needs to be of good quality and to be trusted by both decision-makers and CHWs themselves. A consortium of four partners aimed to document how users- understand, prioritize, and remediate data quality issues through user research. The findings informed the development of the data observation toolkit (DOT) that identifies data quality issues in near real-time while remaining generalizable across platforms.
Methods: A mixed methods approach was used in the user research. Focus group discussions (FGDs) and key informant interviews were used to understand and document the sources of data quality issues, user assignment of priorities, and user perception of remediation. User-driven exploratory data analysis identified quality issues in CHW-collected data.
Results: Criteria for the prioritization of data quality issues and scenarios were developed with users. The prioritization criteria ranked data quality issues from antennal and postnatal care workflows highly in line with increased focus to minimize adverse health outcomes for mothers and babies. Users developed a three-level classification hierarchy with a scenario, cause sub-category, and cause category for management and reporting of identified data quality issues.
Conclusions: Health system users do not only understand the concept of data quality but the identification, classification, prioritization of data quality issues, and remediation and remediation and therefore provide a good entry point for the design of systems that address data quality.

Keywords: user research, data quality, data observation toolkit, community health work, scenarios

6 Introduction

6.1 Background

In primary healthcare, poor-quality data leads to poor patient care like delayed and missed interventions, invalidation, and non-reproducibility of research results while limiting value from such data in decision-making [1]. A taxonomy of the costs of poor-quality data [2], outlines costs associated with data use and quality assurance of such data. Costs from the use of poor quality are both direct in verification, re-entry, and compensation costs; and indirect in wasted resources, wrong decisions, and loss of data trust. Assuring data quality is documented to incur prevention, detection, and repair costs.

As frontline health workers, community health workers (CHWs) are dedicated to delivering quality primary healthcare to their communities. Service delivery by CHWs leverages their close relationship with the community they serve thereby giving authority to the health services they provide. In the course of delivering services, CHWs routinely generate data that is crucial for decision-making. Even though CHW-collected data is widely considered to be of poor quality[3], [4], the study by Otieno et al. [5] documented relatively good agreements between CHW-collected data and those collected by research assistants.

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The centrality of CHWs and data users is apparent in the approaches proposed and used to improve the quality of data within community health systems. Such approaches include using tools in languages understood by CHWs, training in data management for both CHWs and their supervisors, supportive supervision to CHWs, use of functional equipment, regular data quality audits, and feedback across all levels of the data management hierarchy [6].

For CHW-collected data to be used, two conditions need to be fulfilled. First, that the data is of high quality, and; second, that the data is trusted by the decision makers and the data users – including the very CHWs that collected the data especially if interventions are to be undertaken by the CHWs. The design of data quality systems and tools should therefore involve different data users across the system, including system health managers, supervisors, system designers, system developers, data scientists, and statisticians.

6.2 Purpose

Existing data quality tools either do not automate data quality detection, treat it as a premium feature to be paid for, require a high level of skills to deploy or are generally domain-specific. The survey by Ehrlinger and Wöß [7], for example, discovered only one tool - Apache Griffin, from a pool of 667 as the only one that supports the automation of data quality metrics even though it lacks data profiling capabilities and is difficult to deploy with two experienced computer scientists requiring over a week to complete the full installation. Though extensive, the review in Ehrlinger and Wöß did not include two key tools – Amazon Web Services (AWS)'s Deequ [8] and the World Health Organization (WHO)'s Data Quality Review (DQR) [9]. AWS's Deequ is exceptionally flexible but requires familiarity with programming concepts and an understanding of how to verify that the checks implemented are working as intended. DQR comes in two versions – the DHIS2 version which is highly specialized to the District Health Information Software 2 (DHIS2) and the Excel version which is easy to configure but requires manual inputs from users at every run of quality checks. Open-source tools that support the automated detection of data quality issues, are not domain-specific, are easy to deploy, and support remediation of data quality issues are in our opinion still demanded.

The objective of the user research was to work with users to identify, prioritize, and propose mediation for common data quality issues. Specifically, we intended to work with users to – *(1)* identify and document data quality issues from both paper-based and electronic community health systems; *(2)* develop criteria to prioritize the data quality issues and; *(3)* propose appropriate remediation pathways for the different data quality issues. In this paper, we describe the involvement of users in the design of the Data Observation Toolkit (DOT) with the input from data users and how the design for feedback to CHWs on data quality issues is to be achieved.

7 Materials and methods

7.1 User research setting

The Rockefeller Foundation and UNICEF funded the Intelligent Community Health Systems (iCoHS) consortium consisting of Living Goods (LG), Brac Uganda, Medic, and DataKind to strengthen community health systems. To promote the use of data collected by the CHWs, DataKind, and Medic collaborated to develop DOT. As opposed to existing approaches to data quality, DOT set out to be unique in a number of aspects including that it would – *(1)* sit as close to primary data collection systems as possible; *(2)* be as near real-time (NRT) in identifying data quality issues as possible; *(3)* support feedback to and from CHWs on data quality issues, and *(4)* be generalizable beyond a single digital health system tool.

While DataKind in collaboration with Medic has since continued to develop DOT to be highly configurable and amenable to scaling across platforms and domains such that it is now recognized as a Digital Public Good (DPG) [10], the origins of DOT are in strengthening community health systems. Being recognized by the Digital Public Goods Alliance increases the visibility, support for, and prominence of open projects such as DOT that have the potential to tackle global challenges. To become a digital public good, all projects are required to meet the DPG Standard [11] to ensure that projects truly encapsulate open-source principles. The first version of DOT was designed and released for its first deployment with the

Uganda Ministry of Health. To achieve the technical objectives of DOT, the development process was heavily informed by users through user research.

7.2 Category of users, sampling, data collection, and analysis

The user research was done with a range of community health systems users. We engaged with users representing different cadres - health managers, supervisors, designers, data scientists, and statisticians. These users represent different interests at their varying levels of data use. The users were sampled purposively from organizations that either run or support the deployment of the community health toolkit (CHT) [12]. Data was collected during interview sessions using interview guides for each of the different user categories. We used Miro [13], the collaboration platform, to collaborate during the synthesis of the research findings and prioritization of viable concepts. Using thematic analysis, we reviewed notes, coded key points, categorized the codes, and eventually clustered the codes.

7.3 User research process

User involvement in the development of DOT (Figure 1) was a continuous process from user research to user acceptance testing. A mixed methods approach was used for the research.

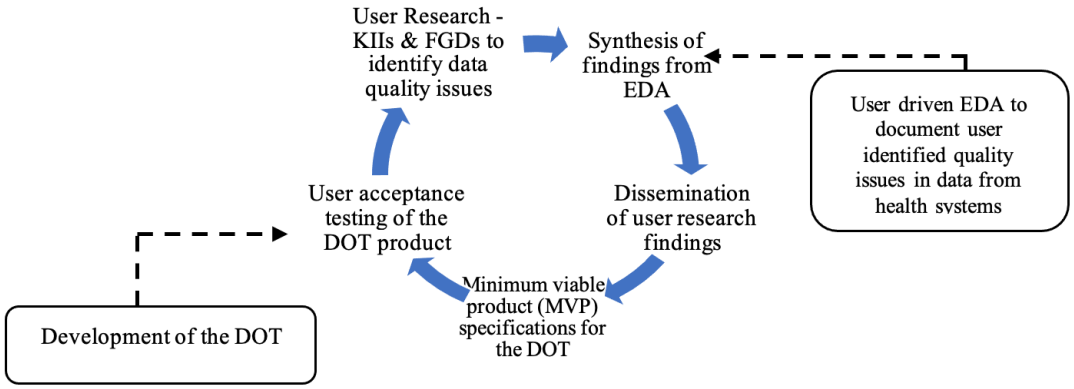

Figure 1: User involvement in the development of the DOT

The user research process (Figure 1) involved the following key steps:

Qualitative methodologies- focus group discussions (FGDs) and key informant interviews (KIIs) were conducted to better understand why some questions and data points were deemed problematic and thus prone to errors. The FGDs and KIIs were used to understand how CHWs think about the quality of the data they collect and the challenges they face and to further seek recommendations from them on how these could be solved.

Quantitative data analysis- was used to determine system usage trends and data points with huge variances. The exploratory data analysis (EDA) helped inform the areas that were prone to errors e.g., measurements of temperature readings. Data analysis was undertaken with the input and leadership of technical system users, especially data scientists, and statisticians.

Synthesis of findings- both the EDA and user research were analyzed and a prioritization matrix was developed to select the data quality issues of areas of focus. Inclusive design research was employed throughout the process to ensure that prioritized areas were significant to all stakeholders including CHWs, supervisors, and data consumers. During the synthesis of the findings, a taxonomy was developed for the data quality issues for ease of management. The findings were disseminated and reviewed to form the basis of the development of the specifications for the minimum viable product (MVP) of DOT that would automate the identification and remediation of data quality issues. The remediation pathways for the problematic data points were documented in collaboration with the users as were the support required for the different cadre of users like data quality visualizations and tasks management.

User acceptance testing (UAT)- was undertaken on the developed toolkit to verify that the DOT MVP product met the needs of the end-user, with scenarios and data sourced from data from actual deployments of community health systems.

8 Results

8.1 Taxonomy for data quality issues

The user research not only generated a set of data quality scenarios but also developed a management structure for them referred to as the taxonomy for inconsistent or problematic (IoP) data. The classification structure for the data quality issues outlines scenarios, cause sub-categories, and cause categories. The organization structure (Figure 2) was the result of anticipated reporting needs expressed by CHW supervisors and the other data users.

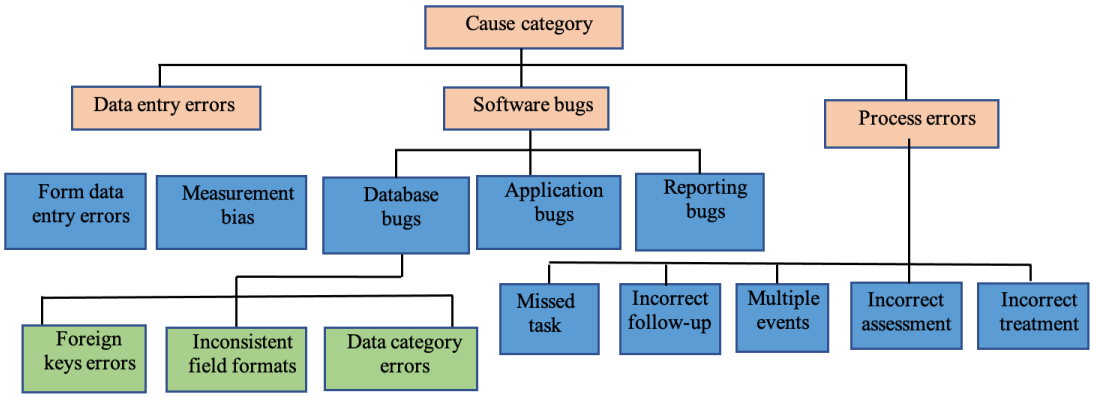

Figure 2: Taxonomy for the inconsistent or problematic (IoP) data with sample scenarios (*green boxes*) cause sub-category (*blue boxes*) and cause category (*orange boxes*).

From the taxonomy (Figure 2), each scenario supports infinite data quality tests. Three specific terminologies were developed for the taxonomy- cause category, cause sub-category, and scenarios. Each data quality issue was assigned a scenario. A scenario defines potential data quality issues that could be expressed in data. Examples of scenarios in the context of data from community health systems include – missing fields, inconsistent data, duplicate data, missed follow-ups, and missed referral visits. Every scenario belongs to one cause sub-category that provides a first-level grouping. Multiple sub-categories are then grouped to form a cause category that denotes wider causes of data quality issues. Three main cause categories were documented during the user research – data entry errors, software bugs, and process errors.

The taxonomy was developed from the bottom-up with users with scenarios defined ahead of determining the appropriate cause sub-categories each belonged to. The scenarios themselves represent different data quality issues for different users.

8.2 Prioritization criteria

A four-criteria prioritization matrix (Table 1) was developed with the users. In actual implementation, the criterion- ease of implementation was evaluated separately for both programmatic and product's ease of implementation.

Table 1: Prioritization criteria

Criteria	Criteria description
Likelihood of occurrence	How likely/frequently is the scenario observed?
Impact	How does the occurrence of the scenario affect the health worker and other data users?

Availability of data	Is there data available to indicate the occurrence of the scenario?
Ease of implementation	Are we able to implement any remediation measures and how easy is it? This criterion was evaluated for both product and programmatic implementations.

8.3 Prioritization of data quality issues

A summary of user-assigned priorities for 22 data quality issues based on a 10-point rating system for each of the user-generated criteria (Table 1) is provided in Table 2.

Table 2: Sample results from user's prioritization of data quality issues

No	IoP scenario	Scenario Description	Likelihood of occurrence	Impact	Availability of data	Ease of implementation		Priority Score	Rank
						Product	Programmatic		
1	Missed task	Pregnancies missing delivery reports	7	10	10	10	9	9.2	1
2	Form data entry error	Invalid entry of expected delivery dates by CHWs	8	10	9	9	8	8.8	2
3	Missed task	Patients (mothers and newborns) with danger signs missing referrals	8	9	8	10	9	8.8	2
4	Missed follow-up	Expectant women are not followed up according to the MoH/WHO guidelines.	8	10	7	8	7	8	4
5	Form data entry error	Incorrect entry of last menstrual period (LMP)	5	10	10	6	8	7.8	5
6	Multiple events	Duplicate family planning (FP) registration	8	6	10	7	7	7.6	6
7	Form data entry error	CHWs key in incorrect future/ past event dates	5	7	10	8	7	7.4	7
8	Form data entry error	Birth dates clustering around certain dates/months	7	5	10	7	7	7.2	8
9	Incorrect treatment	New family planning on active pregnancies	8	5	7	7	9	7.2	8
10	Form data entry error	Subsequent contradictory information captured on households e.g., rapid shift in toilet ownership	7	6	10	7	5	7	10
11	Form data entry error	CHWs report ANC visits that have very close dates than expected.	7	6	8	6	8	7	10
12	Time/Date incorrect on CHW's phone	CHWs submit data with the wrong time settings on their phones	5	10	10	3	6	6.8	12
13	Duplicate data entered	CHWs register a pregnancy more than once	5	8	8	4	8	6.6	13
14	Multiple events	Multiple same-day records of PNC visits during the PNC period.	8	5	7	6	7	6.6	13
15	Form data entry error	Recapture of immunizations already administered from checkboxes in the application.	5	6	6	8	8	6.6	13
16	Duplicate data entered	CHWs register households/ patients multiple times.	3	7	8	6	8	6.4	16
17	Missed task	A CHW under/over reporting compared to others	7	5	7	6	7	6.4	16
18	Measurement bias	Temperature readings outside the normal ranges	5	9	7	7	3	6.2	18
19	Measurement bias	Inaccurate counts of respiratory breaths lead to under or overdiagnosis of childhood pneumonia	5	9	8	5	3	6	19
20	Incorrect treatment	A subsequent family planning registration for the patient earlier on tubal ligation.	3	5	8	6	7	5.8	20
21	Application bugs	Data columns/fields renamed over time	3	5	7	5	7	5.4	21
22	Duplicate data entered	Multiple forms of the same activity for the same child are submitted within the same day.	3	5	8	6	4	5.2	22

Higher priority scores (Table 2) implied a higher weight for the need to address the identified data quality issue. The criteria – *ease of implementation* was used to indicate the users' judgment of the feasibility of remediating a data quality issue even for cases when it could have adverse impacts. We use the following two examples to illustrate user research findings on the prioritization of data quality scenarios:

The IoP scenarios - Nos. 1-5 (Table 2) are derived from antenatal care (ANC) and postnatal care (PNC) workflows – two workflows for which data quality is key. Missing delivery reports, especially if negative outcomes should have been recorded, are for example considered a lost opportunity to save a life in the future [14] while ANC and PNC are considered critical care phases for pregnant mothers and newborns [15], [16], [17].

The IoP scenario No. 12 (Table 2) which is described as- *Time/Date incorrect on CHW's phone* was described by Statisticians and Data Scientists to happen for different reasons e.g. – turning off *automatic time and date phone settings*, removing the phone battery to install stand-by batteries, and having the wrong time zone setting on the phone. The consequence of this scenario is the pervasiveness of data quality issues that arise when new data collected comes in with wrong timestamps thereby altering the sequence of events like invaliding planned follow-ups, referrals, and treatments that are created from tasks that are used to offer reminders to CHWs. Interestingly, users consider the impact of the scenario to be high (10/10), and the likelihood of occurrence to be moderate (5/10). Furthermore, in terms of remediation, the users indicated their expectations that the scenario is easier handled through programmatic interventions like CHW training on how to identify the issues compared to building out product features to handle this.

9 Discussion

CHWs and other users of community health systems both have a role to play in improving the quality of the data they gather as part of supporting the delivery of healthcare. It is for example remarkable that users, most likely based on their past experience, prioritized the remediation of data quality issues from ANC and PNC workflows.

Remediation is generally assumed to be external to the data quality tools despite it being the ultimate aim of data quality assessments. Our user research, however, indicated that users have a good idea of how to classify data quality issues, which classification could serve as a framework for remediation, which tools like the DOT can leverage. Interestingly, when it comes to remediation, programmatic and product teams hold different views on the ease of implementation of remediation measures, a fact that should guide the design of data quality tools. As steps are taken to professionalize and fit CHWs into the healthcare system, there will be a greater focus on the quality of the data they collect. Tools that are developed with CHWs and other data users to track and remedy data quality issues like DOT will have an increased chance of adoption as they validate, quantify, and address quality issues well understood by their primary users.

We anticipate additional user insights as we advance the user research to evaluate the user experience in the deployment and use of DOT with data collected through observations and interviews.

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Statement on conflicts of interest

The authors have no conflicts of interest to declare. All co-authors agree with the contents of the manuscript, have no financial interest to report, and certify that the work is not under review at any other publication.

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Journal of Health Informatics in Africa

Achieving effectiveness in result-based financing through digital transformation of the verification process: Evidence from Burundi

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Background and Purpose: While Burundi has implemented Electronic Medical Record on a large scale, few actions have been initiated for their meaningful use targeting the effectiveness and efficiency of digital interventions other than those aiming for the improvement of quality of care. Among the very limited initiatives undertaken in this regard, there is the digital transformation of the performance-based financing verification process. This study aimed to investigate the impact of this new digitalized verification approach.
Methods: A retrospective longitudinal study was conducted on 27 hospitals including 11 hospitals where verification is digitized and 16 hospitals where verification was still performed using hard copy records. Data were extracted from the OpenRBF database. The two judgment criteria were changes in amounts paid and in the percentage of errors detected during verification. Spaghetti plots were generated, and repeated measures analysis of variance (ANOVA) was used to assess whether changes were different in the two study groups.
Results: The main result was that the digital transformation reduced the amount paid to hospitals in a statistically significant way ($p = 0{,}0003$). At the same time, the percentage of errors detected by the auditors didn't change in a statistically significant manner ($p = 0{,}724$). The average monthly amount paid to a hospital undergoing digital verification was reduced by 14.9 million Burundian francs in the six months following the start of digital verification.
Conclusions: Digital transformation of the purchasing process for health services is very promising. Our findings suggest that the implementation of digital verification should be scaled up at the national level, given its potential benefits.

Keywords: Digital transformation, Verification process, Performance-based financing, Burundi.

1 Introduction

Digital transformation is revolutionizing the healthcare sector worldwide[1], [2]. First, it improves the quality of care by supporting the decision-making process, improving patient safety, enhancing patient follow-up, and thus increasing patient satisfaction[3]–[5]. Secondly, it is reducing health disparities by bringing new skills to very remote areas through telemedicine[6]. In management, it contributes substantially to improving patient care coordination and increasing the cost-effectiveness and cost-benefit of health interventions[7].

Despite its great potential, digital transformation can only be fully exploited in the health sector if digital health interventions are employed meaningfully [5], [8]. The reason is that if EMRs are only used to store data in the same way as they were in paper format, the full potential of digital transformation will not be realized.

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Since 2015, Burundi made health facility computerization a priority and established a national health informatics development plan to materialize this commitment[9]. To date, 75% of public hospitals are computerized and a phase of health center computerization has been started. The OpenClinic GA software is used for medical record management, billing management, and health facility management[10].

While Burundi widely uses Electronical Medical Records (EMRs), few studies end actions have been initiated for their meaningful use targeting effectiveness and efficiency of interventions other than quality of care. Among the very limited initiatives undertaken in this regard, there is the digital transformation of the performance-based financing verification process, a very crucial process given the amounts involved, the large number of health facilities to be visited each month and the pressure to do so in timely manner in order to pay those health facilities for which PBF is the main source of income. While the process of billing verification was previously carried out using hard copies of various reports and registers, a digital verification experience using OpenClinic GA software has been implemented in a few hospitals in order to take advantage of the country's large scale EMR implementation.

However, there was little evidence of the impact of this digital transformation on the BPF purchasing process. Thus, the aim of this study was therefore to investigate the impact that the digitalized auditing approach had on this purchasing process.

2 Materials and methods

2.1 Study design

A retrospective longitudinal study was conducted to assess the effectiveness of the digital transformation of the performance-based funding verification process.

2.2 Sample size

For this purpose, a total of 27 hospitals were selected for the study, including 11 hospitals where verification is performed using OpenClinic GA software and 16 hospitals where verification is still performed in a traditional way using hard copy records. These last hospitals were selected from the same provinces or regions as those in the group where verification is performed in OpenClinic GA. Hospitals in each group were randomly selected.

2.3 Digital transformation of PBF verification process description

Prior to 2017, the verification process under performance-based financing (PBF) was structured as follows: each health facility had to prepare a monthly summary of quantitative services provided and submit it to provincial verification committee. These summaries were then checked by that committee by comparing them with facility records in the registers and other hard-copy documents to verify reliability and validity of reported data.

In 2017, while Burundi government, with the support of its technical and financial partners, had decided to improve hospital management information system (HMIS) by computerizing its hospitals, it was found that data completeness in OpenClinic GA (the software used for hospital management in Burundi) was low compared to records in paper registers. This was linked with the double data encoding by the hospitals on paper and in OpenClinic with more emphasis on paper registers, which were used for performance-based funding verification.

Considering that this represented a threat to sustainability of health facilities' computerization, given the need to improve data quality, and necessity to eliminate double data encoding, discussions were logically initiated between stakeholders to transform paper verification into digital verification, starting with a pilot phase in three hospitals.

After a positive evaluation of the digital verification pilot phase in 2017, it was decided by the Ministry of Public Health and AIDS Control that verification process under PBF will henceforth be transformed into digital verification in all computerized hospitals.

Thus, digital transformation of verification process was conducted in five steps as follow:
Stage 1: Development of PBF-specific reports in OpenClinic GA
Step 2: Hospital health information system managers training on PBF report production.
Step 3: National technical committee members training on digital verification.
Step 4: Provincial verification and validation committee members training on digital verification.
Step 5: Implementation of digital verification in all computerized hospitals.

2.4 Data source

PBF validation and purchasing data were extracted from the OpenRBF database used by the national technical unit in charge of managing the performance-based financing strategy.

2.5 Study variables

For each hospital, changes in the amounts paid and in the percentage of errors detected on five indicators during verification have been the criteria used to judge the effectiveness of the verification process after digital transformation. These five indicators were the numbers of “under 5 years” outpatient visits, "over 5 years" outpatient visits, "pregnant women" outpatient visits, number of days of hospitalization for pregnant women and number of days of hospitalization for children under 5 years. Measurements were taken before the digital transformation of the verification process and at 3 and 6 months after computerization.

2.6 Statistical analysis

Analyses were performed with R-4.3.0 software. Spaghetti plots were generated to graphically assess the evolution and then repeated measures analysis of variance (ANOVA) was used to assess whether changes in judgment criteria were different in the two study groups. Finally, evolution was considered different between the two groups in case of $p<0.05$.

3 Results

3.1 Monthly payment trends for hospitals under performance-based financing

The trend graph (spaghetti plot) shows a downward trend in the amount paid for each hospital between T(0) and T(6) in the group of hospitals undergoing digital verification. However, there is a static trend for the hospitals in the group undergoing non-digital verification. This suggests that over time, the amount paid seems to decrease for the group of hospitals undergoing digital verification while it remains constant for the group of hospitals with traditional hard copy-based verification (Figure 1).

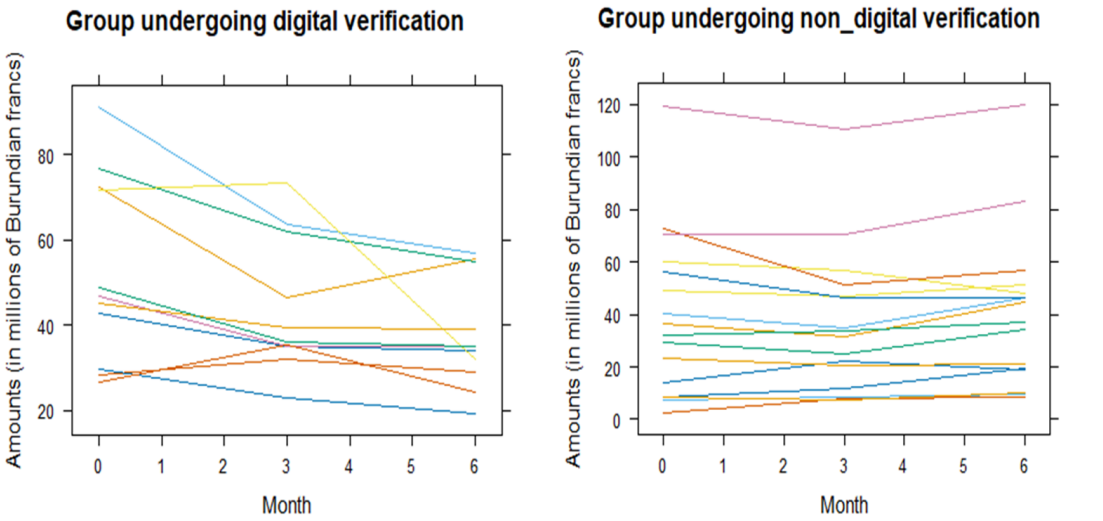

Figure 1: Spaghetti plot showing monthly payments over time for each hospital in the group undergoing digital verification (left) and the group undergoing non-digital verification (right). Each broken line represents the change in payment for one hospital.

3.2 Trend in the percentage of errors detected during the verification process

Except for a few hospitals, the spaghetti plot shows a constant trend in the number of errors detected in each hospital between T(0) and T(6) for the hospitals of the two groups compared. This indicates that over time, the number of errors detected seems to remain constant in the two compared groups (Figure 2).

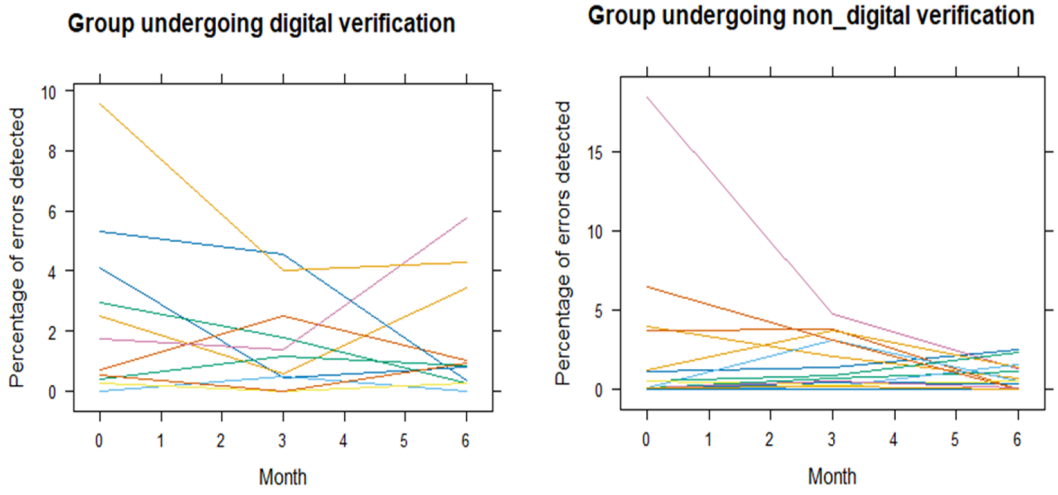

Figure 2: Spaghetti plot showing errors detected over time for each hospital in the group ungergoing digital verification (left) and the group undergoing non-digital verification (right). Each broken line represents the change in detected errors for one hospital.

3.3 Comparison of changes over time in monthly FBP payments by verification type

Analysis of variance for repeated measures showed a p=0.0003 for monthly payments. The average monthly amount paid to a hospital undergoing digital verification was reduced by 14.9 million Burundian francs

(5 240 USD) in the six months following the start of digital verification while it was increased by 1,6 million Burundian francs in the group undergoing non-digital verification.

Table 1: Comparison of changes over time in monthly FBP payments by verification type

	Baseline (T0)		6 mounths (T6)		Mean difference between T(6) et T(0)	ANOVA*	
	Mean	SD	Mean	SD		F value	p-value
Monthly payments in the group of hospitals undergoing digital verification	52,7	21,9	37,8	12,8	-14,9	17.57	0.0003
Monthly payments in the group of hospitals undergoing non-digital verification	39,4	31,2	41	29,3	1,6		

*Repeated measure analysis of variance, significance at $p < 0.05$.

SD, standard deviation.

3.4 Comparison of changes over time in errors detected during the verification process by verification type

Repeated measures analysis of variance showed $p = 0.724$ for errors detected during verification.

Table 2: Comparison of changes over time in errors detected during the verification process by verification type

	Baseline (T0)		6 mounths (T6)		Mean difference between T(6) et T(0)	ANOVA*	
	Mean	SD	Mean	SD		F value	p-value
Errors detected in the group of hospitals undergoing digital verification	2,55	2,89	1,62	1,94	- 0,93	0,128	0,724
Errors detected in the group of hospitals undergoing digital verification	2,25	4,71	0,76	0,82	-1,49		

*Repeated measure analysis of variance, significance at $p < 0.05$.

SD, standard deviation.

4 Discussion

This study aimed to assess the impact of the digital transformation of the verification process under the performance-based financing strategy in Burundi.

Our results suggests that there is a difference in the change in the amount paid over time between hospitals undergoing OpenClinic GA-based verification and those where the verification process is based on hard-copy reports ($p = 0,0003$). They also showed that there is no difference in the trend of detected errors over time between the two groups ($p = 0,724$).

The main result was that the digital transformation reduced the amounts paid to hospitals in a statistically significant way, while the percentage of errors detected by the auditors did not change in a statistically significant way. This probably means that hospitals were overbilling and digital transformation has stopped this practice. Also, undetected billing errors could be suspected.

Another important fact found is the magnitude of saved costs. With this digital transformation of the verification process, the average monthly amount paid to a hospital undergoing digital verification was reduced by 14.9 million Burundian francs (5 240 USD) in the six months following the start of digital verification, which is a significant saving brought by the meaningful use of information technology in the health sector. As in this study, other authors have found that digital health technologies implementation saves costs in the health sector[11]–[13]. A complete migration to digital verification in all computerized hospitals should be considered, as it will allow the country to benefit from the advantages of its large scale EMR implementation.

5 Conclusion

This study presented a meaningful use of digitalization in the health sector in Burundi with the digital transformation of the purchasing process for health services under performance-based financing. It demonstrates that the digital transformation of the purchasing process for health services is very promising. Our findings suggest that the implementation of digital verification should be scaled up at the national level because of its potential benefits.

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Statement on conflicts of interest

The authors declare that they have no competing interests.

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Journal of Health Informatics in Africa

Leveraging Digital Channels to Build Health Worker Capacity at the Last Mile

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Background and Purpose: Country health system challenges that prevent regular training for frontline health workers (FHWs) include high cost of manual training and lack of resources. These challenges prevent FHWs from receiving adequate supervision. Training materials need to be updated with the newest clinical protocols, which can be challenging for paper-based manuals. In-person training leads to the disruption of service delivery. The basic use of digital channels can address these challenges.
Methods: A scoping review was conducted in which a literature review and stakeholder interviews were done to identify best practices of using digital solutions for FHW capacity building.
Results: Primarily, digital channels have been applied for in-service training. A small percentage of examples apply digital channels for pre-service training, and when doing so, it's combined with an in-person component. There was enthusiastic acceptance of digital tools among FHWs, evidence of knowledge gained, and higher motivation/retention rates. FHWs were eager and they appreciated the convenience/flexibility of the digital solution. Evaluation regarding the uptake of content needs to be simple for low-literacy FHWs. Monitoring and evaluation of knowledge acquisition can be seen in the form of pre and post-tests. There is not much known regarding knowledge retention beyond a short-term period.
Conclusions: There is evidence that using digital channels for FHW training contributes to capacity building, an essential building block for strengthening the health system. The digital channel chosen for training will need to be customized to suit the needs of the FHW based on different contexts and requirements, digital literacy level and cadre of health worker.

Keywords: Health Workforce, Digital Technology, Digital Divide.

1 Introduction

1.1 COVID-19 Pandemic and the Effect on the Global Health Workforce

Health systems are highly labour intensive and depend on the crucial role that health workers play in performing or mediating most of the health system functions [1]. There is no dearth of evidence in the literature regarding the correlation between the availability of health workers and quality of care and population health outcomes [2–6]. However, many low- and middle-income countries (LMICs) have been facing acute shortages and inequitable distribution of skilled health workers that impact the delivery of essential health services- including services for health promotion, disease prevention, diagnosis, treatment, rehabilitation, and palliation. The World Health Organization (WHO) has estimated that at least half of the world's population cannot obtain essential health services due to a global shortage of health workers [7].

More than three years since WHO declared COVID-19 as a pandemic, LMICs health systems are grappling with many challenges responding to the evolving and reoccurring challenges of COVID-19 while ensuring the continuation of essential health services. WHO has been tracking and monitoring the extent of the disruptions to these essential services because of the pandemic worldwide and have conducted four rounds of surveys from 2020 to 2023. Based on an interim report released in May 2023, overall, 84% of the 125 countries and territories participating in the survey reported some kind of disruption to services during October to December 2022 [8]. Countries are facing a "crisis in human resource for health" due to

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the lack of availability of qualified health care workers, distribution of health care workers where they are most needed, and the performance of health care workers, including their productivity and the quality of care they provide. Thus, strengthening training programs for health workers is pivotal to increase the number of qualified health care providers and to improve service quality, especially while the world is recovering from the long-lasting effects of the COVID-19 pandemic on universal health coverage and the Sustainable Development Goals (SDGs) [1].

1.2 Training the Cadres of the Global Health Workforce

The global health workforce consists of many cadres of health workers including community health workers, nurses, midwives, among others. Training requirements for each cadre vary, however, no matter what cadre of health worker is being discussed, training them is expensive, time-consuming and may require providers to temporarily leave their work. Additionally, as the burden of the effects of the pandemic continues to fall on the shoulders of health workers, an unprecedented number of responsibilities and competencies are expected from them, which has never been at this level before.

Currently, the health workforce training curricula is focused on building competencies either during pre-service training or during in-service training. Pre-service trainings are defined as recommended pre-qualification curriculum-based training prescribed by regulatory bodies for preparing health care workers during their initial education and for certifying professionals for practice [9], whereas in-service training is a regular process to refresh, reinforce or update knowledge, skills, and competencies. In order to empower health workers with the right competencies to deliver safe and effective services, a combination of both pre-service and in-service training is optimal. Digital health tools that support learning using electronic platforms have been identified as a potential method to help meet this standard while addressing the challenges of regularly training the health workforce entails [10].

1.3 Digital Health Platforms

The rapid development of numerous new innovations and technologies is undeniable and has recently taken a strong foothold in the public health and healthcare field. With the continued growth in mobile network coverage, advancements in mobile technologies and applications, and a rise in new opportunities for the integration of these technologies into existing health services, the use of these digital health tools to transform health service delivery has mass potential [11]. Based on 2020 data, in most regions of the world, more than 90% of the population has access to a mobile-broadband network [12]. In fact, more households in low-income countries own a mobile phone than have access to electricity or clean water [13]. In a 2021 report, The Global System for Mobile Communications Association (GSMA) has estimated that by 2025, mobile internet penetration will rise to 40% in sub-Saharan Africa using 3G, 4G and 5G (62%, 29%, and 3% of connections) [14]. The number of Internet users has also tripled in the last decade: from 1 billion users in 2005 to approximately 4.1 billion users at the end of 2019 [15]. Combining the need for strengthening the qualified health workforce with the ubiquitous nature of mobile technologies, leveraging digital tools for learning has great potential.

Although the potential of leveraging digital technologies to address the challenges of training the health workforce either in a pre-service or in-service model is vast, there is limited knowledge and acceptability on the use of digital learning platforms in low-bandwidth settings in LMICs. Additionally, there is relatively little evidence regarding the minimum requirements the digital learning platform should meet and what considerations should be considered in the assessment and deployment of these platforms. To address this gap, we conducted a scoping review that included a review of the current literature and case studies and conducting stakeholder interviews. The objectives of this review were to:

- List existing digital health technologies used for learning programs for frontline health worker training, specifically in the context of low bandwidth settings
- Identify platforms and interventions in community health where there has been an application of different digital messaging channels
- Summarize evidence on the minimum prerequisites that need to be met for the deployment and assessment of the digital learning platforms

- Based on the gathered evidence on various applications, discuss what potential considerations and learning platforms are available for frontline health worker trainings

This paper provides a summary of the current evidence base around using digital health tools for capacity building and upskilling of the health workforce in LMICs in low-bandwidth settings. Additionally, insights from stakeholder interviews are integrated to support any future efforts in transforming learning approaches for healthcare workers to a digital platform.

2 Materials and methods

2.1 Scoping Review

In order to provide a summary of the current evidence base, the first step was to conduct a scoping review of the literature. For this review, the scoping review methodological framework recommended by Arksey and O'Malley and Levac et. all was followed [16,17]. Additionally, the reporting guideline PRISMA Extension for Scoping Reviews and the PRISMA guidelines were adhered to [18,19]. The World Bank income classification was used to determine if a country fits the LMIC inclusion criteria [20]. For the purposes of this review, publication types included peer-reviewed journal articles, conference papers, book chapters, dissertations, grey literature, and technical reports. Frontline healthcare workers included community health workers or advisors, midwives, and nurses. Digital learning platforms were defined as a digital tool used to train health workers on either a new topic or to update them on new information or changes to clinical protocols. Low bandwidth settings were defined as areas where resources were low that in turn led to either slow internet speeds or lack of access to continuous connectivity. Any finding that did not meet these inclusion criteria was discarded. Studies that focused on training physicians were also excluded.

The following databases were used to conduct the peer-review literature search: PubMed, Science Direct, Scopus, Google Scholar, and Web of Science. The sources selected for the grey literature search included technical reports published by international organizations, such as WHO, UN agencies, USAID, GAVI, CDC, Global Fund, the Bill & Melinda Gates Foundation and NGO/civil society groups. The pre-defined key terms used to search the databases and grey literature include "digital health" OR "digital platforms" OR "e-learning" OR "mHealth" AND "health worker" OR "community health worker" OR "community health" AND "learning" OR "training".

Initially, titles and abstracts were screened to ensure that the inclusion criteria are met. Once an initial pass was made and the publication had been selected, the full article was thoroughly reviewed and then a final decision was made to select the publication and chart it. All searched publications, after ensuring that they meet the inclusion criteria, were extracted to Zotero [21]. The variables that were extracted and charted include: link to the publication, title, authors, first author affiliation, country of first author affiliation, publication year, study population, the country of the study conducted, geographic extent (national, sub-national, local), sector (e.g. Health, WASH, Education), health outcome (e.g. incidence, mortality, morbidity), WHO Health System Challenge, digital messaging channel (I.e. app, SMS, message-based, tablet, computer, IVR), type of CHW training, minimum requirements for adaption, deployment plan, assessment of training uptake, content library (y/n and open access), and takeaways.

2.2 Stakeholder Interviews

The second step of the scoping review included interviews with key stakeholders currently applying digital technologies to train healthcare workers in LMICs. A total of 25 hour-long interviews were conducted with up to three representatives from each stakeholders' organization (Appendix 1). The stakeholders were contacted via email and asked for their interest and consent to be interviewed for the scoping review. At the start of the interview, each individual was explained the purpose of conducting the interview and how the information they share during the hour will be applied. A pre-determined set of seven questions (Appendix 2) was used to guide the discussion. Detailed notes of each interview were taken.

3 Results

The scoping review (n=36 articles or case studies and n=25 stakeholder interviews) reveals an uncoordinated and highly varied approach to capacity building for health workers using digital tools across approximately 20 countries, mostly in Africa. Whether it is the lack of a unified and accepted terminology to define this field or the absence of clear categorizations of digital education methodologies, a standardized or "best practice" approach has not been identified [22]. Example implementations from LMICs in low bandwidth settings derived from published articles, case studies, and stakeholder interviews allude to potential benefits of digital trainings, however high-quality evidence and limited generalizability does not allow for a conclusion to be made on its effectiveness. Nevertheless, enthusiastic acceptance and potential of digital tools among frontline health workers can be seen across the board. Several areas were identified during the scoping review that can help inform the steps, considerations, and potential benefits at each point of implementation of health worker training programs using digital tools.

3.1 Approaches to Digital Education

The scoping review identified different approaches to training and education via digital technologies. These approaches are known as digital education and blended education [22]. Digital education, which is also known as e-Learning in the literature, is defined as teaching solely by a digital technology. The teaching modality can be a basic conversion of content into a digital format, i.e., a PowerPoint presentation, to a complex deployment of digital technologies, i.e., artificial intelligence. The second approach is known as blended education or blended learning. This approach includes digital education but also integrates traditional education components, such as face-to-face learning, as part of the curriculum. Blended education does not dictate what share of the curriculum is digital education and what share is traditional education. Thus, blended education can take on many diverse formats. It is important to note that education delivered via in-person interaction supported by digital education aids such as images or charts are not considered blended education but classified as traditional education.

3.2 Training Delivery Modalities

As previously stated, a highly varied approach has been taken across the examples identified in the scoping review on how educational content has been delivered to health workers on digital platforms. Given that these numerous approaches, otherwise known as modalities, have several working definitions, WHO has condensed them into six categories in an attempt to unify the digital education field [22]. These six categories include 1) Online digital education; 2) Offline Digital Education; 3) mLearning; 4) Interactive Voice Response (IVR); 5) Massive Open Online Course (MOOC); and 6) Serious Gaming and Gamification (SGG). These low-bandwidth modalities are presented in Table 1, along with their definitions and what requirements need to be met for the successful implementation of the chosen modality [22].

Modality	Description
Online Digital Education	Often referred to as "online" or "web-based," this modality of training requires the use of a "transmission control protocol" (TCP) and an Internet Protocol (IP). With this feature comes the ease of updating training content, however, this modality requires continuous bandwidth and high data use requirements. An advanced phone is required, and some users may be cautious of the storage space that the training requires from their phone. Note that this modality may also have offline capabilities.
Offline Digital Education	This modality does not require internet bandwidth or access to local network connection. The technology used to deliver this education can vary, including a phone, USB stick, external hard disc, or a CD-ROM. This modality can be cost-effective if users are using their own device, however, if devices need to be supplied, the intervention can become expensive.
mLearning	Using real-time, two-way communication, this modality allows for learning across multiple contexts through social and content interactions via smartphones. Social media

	platforms are most commonly used for this. The end-user needs to use their own data bundle, which incurs personal costs, however mobile network operators (MNOs) are increasingly providing affordable data bundles.
Interactive Voice Response (IVR)	In the context of healthworker training, this modality uses a "push" mechanism where end-users receive scheduled calls to listen to the training modules. This can be delivered using either a basic mobile phone or smartphone, but both require mobile network connectivity and the ability to receive phone calls. In certain scenarios, calls can be free or subsidized via MNOs.
Massive Open Online Course (MOOC)	This modality delivers online courses designed for computing devices that require internet bandwidth and can be delivered in large numbers across diverse geographic regions. Besides its scalability, this modality is affordable and allows content creators to update content easily.
Serious Gaming and Gamification (SGG)	By involving a competitive activity, this modality uses games or gamification to promote learning. This approach strengthens the learning experience by including in-built motivation techniques and increases engagement and attention. Due to the potential high cost of equipment, this modality has not been applied much in LMICs, however, this modality can be implemented on the aforementioned modalities as well.

Table 1: Digital Training Modalities and Definitions

Note: This table has been adapted from WHO Digital Education for Building Health Workforce Capacity Guidance

The selection of training delivery modality needs to consider many factors including: 1) cadre of the health worker; 2) the training content required; 3) level of expertise; 4) compatibility with the digital infrastructure in the country; 5) costs and financing available; and 6) the ability of the intended end-user to access the training. Resoundingly, stakeholders emphasized that digital trainings can be classified in various ways, but still have the same intended outcomes.

3.3 Low Bandwidth Training Platforms

The digital health field has grown exponentially because of the COVID-19 pandemic, and thus many digital health tools can be found in the ecosystem. Consequently, when examining the literature and case studies, many of these one-off solutions were identified. However, the various deployments did not point or reveal to any one particular training platform(s) as the go-to solution to pick. Nor did any tool reveal to best support any of the six modalities mentioned above. Instead, the theme of choosing digital health tools that can already be found or could easily fit into the existing health system was repeated across the stakeholder interviews. Additionally, both stakeholders and the literature revealed that a platform that trains health workers but also provides additional functionalities such as facilitating communication between health workers, providing them with job aides, and assisting with supervision, supports effectiveness of the training and sustainability [10]. The most common training platforms found in the scoping review are defined and summarized below in Table 2.

Table 2: Digital Training Platforms and Features

Platform	**Description**
CommCare	A digital solution that allows users to build a custom solution to support frontline health workers. Although not specifically created as a digital learning platform, CommCare is a flexible solution that can be adapted for training purposes.
Community Health Toolkit	The Community Health Toolkit (CHT) is a collection of open-source technologies and open access design, technical, and implementer resources that help you build and deploy a digital tool for community health. The focus of the CHT is not just on digital learning platforms, but for digital tools for health system strengthening overall.

LEAP	A mobile learning solution that trains and empowers health workers. This platform leverages the healthworkers personal phone (either basic or smart phone) and integrates both interpersonal and community aspects of learning. By using this platform, learners can go through the content at their own pace and are evaluated through quizzes and practical exercises.
Moodle	An open-source learning platform designed to provide educators, administrators, and learners with a single integrated system to create personalized learning environments. This platform can be used as a web-based or mobile application, has a simple interface, and has both online and offline capabilities.
Mobile Academy	Based on Interactive Voice Response technology, this platform offers anytime and anywhere audio-based learning accessible from any mobile device. The focus of this platform is to improve interpersonal communication skill and refresh knowledge.
OpenWHO	A mobile and web-based application developed by the World Health Organization that uses interactive knowledge transfer through online courses to improve the health workers response in emergencies. The courses include downloadable video lectures that can be viewed offline, quizzes, job aids, interactive exercises, and peer discussion boards.
Oppia Mobile	An open-source mobile learning platform designed for delivering content, multimedia, and quizzes in a gamified setting. The user earns points and badges for completing activities, quizzes and watching videos. All training components can be accessed offline. A text to speech function is included and support is also available for multilingual content.
PepFar Virtual Academy	This platform uses multimedia courses that provides both live and self-paced courses for health workers suited to their skill levels and learning needs. Live courses are delivered through video conferencing tools while the self-paced courses use videos with captions and/or course handouts.
Project ECHO	Led by the University of Mexico, this platform integrates video conferencing to create virtual cohorts with local healthcare teams for continuing education. The training is centered around short didactic knowledge content and case-based learning that emphasizes live discussion and problem solving. A strong focus on adult learning principles is used to guide the online space.
RapidPro	A mobile technology programming tool, RapidPro is a free, open-source software that allows users to easily build and scale mobile-based applications. Sitting on the backend, RapidPro can power SMS, Telegram, and other message-based apps to collect data as well as to send information, such as training content. This platform allows users to design, pilot, and, scale direct mobile outreach services.
upSCALE	This all-encompassing mHealth system has been adapted for community health worker training for the COVID-19 response. Using SMS, the community health workers were prompted that a module on COVID-19 prevention and transmission of risk is available on the upSCALE app.
Viamo	Interactive Voice Response is applied in the format of choice for training: 3-2-1 Service: subscribers can access information by dialing a toll-free short code (i.e., 321) on their mobile device and can easily navigate through a menu of topic options. An average of a 2–3-minute message is delivered in the local language, based on the topic of choice. Remote Training: training modules that are delivered on basic mobile phones via voice. A health worker will receive a phone call at a scheduled time that lasts approximately seven minutes, which includes knowledge sharing as well as comprehension questions to check understanding and participation.
WCEA	The World Continuing Education Alliance is a web-based learning management system that has been specifically designed for the delivery and

	tracking of continuing education. This free platform engages with education providers to provide content to nurses and midwives.
WHO Health Academy	Using a smartphone app, the World Health Organizations mobile learning app was developed for health workers to access knowledge resources created by WHO. These resources include guidance documents, tools, training, and virtual workshops.

3.4 The Potential of Using Digital for Strengthening the Health Workforce

Regardless of the lack of evidence on the best practice for modality and digital tool(s) for implementation of capacity building programs for health workers on digital solutions, this scoping review revealed potential and acceptance towards using digital tools as learning mechanisms to strengthen health worker competencies measured by their attitudes, skills, and knowledge. This potential of digital learning tools can be seen across several factors: 1) it is a feasible mechanism that is convenient and flexible for the healthworker and allows for no service disruption; 2) there is evidence of knowledge improvement; 3) education can be delivered to last mile communities; 4) a continuum of learning can be created; 5) healthworker confidence is shown to be increased, which leads to higher motivation and retention levels; and 6) it is cost-effective.

3.4.1 Convenient and Flexible with No Service Disruptions

The literature revealed health workers enthusiastically appreciated the convenience and the flexibility a digital learning system provides them, as opposed to set-timed classroom-based courses, regardless of pre-service or in-service delivery training programs. Health workers noted that they can determine when they want to access the content and at what pace they would like to review the content [23–30]. Additionally, by completing trainings at the health workers convenience and own-time, the lack of disruption to service delivery was noted across the literature and during the stakeholder interviews [29,31].

3.4.2 Strengthen Health Worker Knowledge and Education Cost-Effectively

Almost half of the journal articles and case studies evaluated improvement in knowledge among the health workers through either self-reporting or through statistical tests. All 17 of the studies reported improvement in knowledge acquisition and some health workers also stated that the trainings helped them provide better service to their patients [23,25,28–42]. The importance of contextualizing and customizing the digital tool to suit the needs of the health workers based on their context as well as the health requirements was a repeated theme among the literature, case studies and stakeholder interviews. The content and the knowledge assessments may need to be simplified for lower literacy adults [43]. Some instances were identified where health workers were not as comfortable or familiar with the technology being used among health workers with lower digital literacy skills and thus it was recommended to have a prior training session [39,43,44]. An additional recommendation to strengthen knowledge gained was to keep health workers engaged till the end of the course by providing incentives such as an SMS prompt and accreditation or certifications [24,35,45].

Peer or group facilitated learning is an essential component of classroom-based settings as it facilitates further knowledge uptake. Since this is not possible when using an asynchronous digital tool, a common methodology reported in the literature to compensate is to conduct group activities or discussions through group chats or boards. This allows health workers to build upon each other's ideas while reviewing the material and allows for them to retain it as well [26,32–34,39,41]. The instructor-learner interaction is also important for retention of new material and should be integrated if possible [32,34].

Although there is supporting evidence of using digital tools for capacity building, many of the papers identified in the literature review as well as among stakeholders interviewed emphasized the importance of classroom-based face-to-face interaction, and that digital trainings should be part of a blended, rather than an alternative approach. Instead, they advocated for digital learning tools to either augment classroom-based trainings or to use it as a viable alternative if circumstances don't allow for face-to-face training [29,33,38,43,46].

3.4.3 Continuum of Learning and Health Worker Confidence at the Last Mile

The literature and case studies revealed that delivering training content on a digital platform allows for health workers to regularly access health knowledge and information. This access creates a continuous and

accessible learning environment. Additionally, since the content is always readily accessible, the health worker can also share the content when at the point of contact with the patient, allowing the health worker to assume the role of a teacher creating a continuum of learning [24,26]. The evidence also shows that by using a digital tool, education can be delivered to more hard-to-reach and remote areas as well as can increase student enrollment in a cost effective manner [20,30,31,47–50]. It is also important to note, though, that the basic use of digital learning tools showed evidence of higher retention rates for health workers and increased motivation and their self-confidence [24,30,39,42,51].

4 Discussion

The potential for digital technologies to support capacity building for health workers, if properly designed and implemented, to improve learning outcomes and deliver education in remote areas while enabling lifelong learning is vast. The changing population demographic as well as the increased disease burden make it more important than ever before to maintain health worker competency throughout their professional lives. Additionally, updating knowledge and skills as new science and technology emerges is crucial. By focusing on the health workers skills and competency, ultimately, the health system will shift towards an integrated people-centered health service [22].

The mHealth literature base is enormous, however specifically when looking at literature for leveraging digital tools for health worker education, some challenges exist, such as lack of high-quality study methodology particularly in LMICs. Although the conclusions are not definite and there are some gaps in the evidence, the literature that does exist supports that digital education can be as effective as traditional education in terms of improving the knowledge and skills of health professionals, under certain circumstances [22]. However, a combination of learning approaches in different contexts and environments will lead to optimal learning outcomes. Currently, it is unclear how using digital technologies for capacity building for health workers affects patient outcomes [22].

The rapid emergence of new technologies along with exponential growth in ownership of mobile devices and connectivity through 3G and 4G in LMICs paves the way for large scale implementation of digital learning tools either on their own or as a part of blended learning approaches. However, there was consensus among the literature, case studies, and stakeholder interviewees that blending digital modalities with traditional learning approaches strengthens the health workforce in a feasible and sustainable manner rather than having digital as a standalone solution. Much of what is seen in the literature are digital learning platforms implemented on a smaller scale. Considering the potential of these tools to facilitate in-service training in low-resource settings where continuous training opportunities are scarce and unaffordable, scaling up and integrating these tools for the health workforce development in the broader health system should be considered. To do so, it is important to address external, system-level, institutional, and individual factors [22].

External factors include the digital health infrastructure available in the country as well as the level of digital literacy in the target population. The population for whom digital tools are developed need to be receptive to adopting innovations and ICT systems, and buy-in from government and non-government stakeholders is important. Without a receptive audience, it is likely that the target population will not pick-up this resource available to them. For system-level factors to be addressed, ongoing health workforce development need to be incorporated and funded as part of long-term health system plans. Investment in the digital infrastructure may also be needed, as well as the promotion of multisectoral collaborations with key stakeholders such as educators, ministries of health, IT companies, and health experts. Institutional factors involve the level of organizational ownership, management support and deployment of training via the appropriate digital learning platform. Lastly, individual factors include the beliefs, attitudes and behaviors of the health workers and the team involved in the implementation of the training as it can highly impact the success of the program's implementation.

Thus, the learnings from the scoping review can be summarized as five key considerations to have planned out before the deployment of a digital learning tool(s) for training the health workforce: (1) technical feasibility; (2) usability; (3) acceptability among users; (4) improvement in health outcomes; and

(5) sustainability. Technical feasibility not only considers the digital health infrastructure of the country, but also includes the barriers and complexities that the health worker would face. Keeping barriers low and complexities to a minimum allows for better uptake. To make the content usable and accepted among the end-users, which in this case is the health worker, there was consensus among the interviewees and literature to apply people-centered principles and co-design the content with the health workers themselves. By considering these factors, ultimately uptake of the content being delivered via the digital learning tool will improve. As previously documented, for the training to lead to improvement in health outcomes, the quality of the content must be the highest possible. Thus, involving educators who are experts in adult learning principles, as well as involving subject-matter health experts are all ingredients that lead to highly vetted training content. Lastly, the underlying principle of sustainability was a theme across the review. Thus, while picking the digital learning tool platform and modality, consider what can be sustained at a large scale and for a long period of time.

Looking forward, the literature as well as the stakeholders in the field have many directions in mind for this field to evolve towards, including but not limited to 1) virtual or augmented reality education for skill development; 2) AI systems to customize the learning experience; 3) using big data to determine where knowledge or skills need to be reinforced; 4) interoperability between systems and 5) replicable results on the evidence of digital learning tools for further investment and scaling. By further investing in digital solutions to continue to build capacity among the health workforce, an essential building block for strengthening the health system, there is potential to improve patient health and population health outcomes while also achieving universal health coverage.

Statement on conflicts of interest

No conflict of interest.

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Appendix 1: Stakeholder Organizations Interviewed

Note: For some organizations, multiple interviews were conducted

Stakeholder Organizations
BBC
Community Health Academy
Community Health Impact Coalition
CORE Group
Digital Campus
Dimagi
Echo Platform
Health Enabled
IntraHealth
John Hopkins University
John Snow, Inc
Malaria Consortium
Medic Mobile
PATH
Stanford Digital Medic
TechChange
UNFPA
UNICEF
University of North Carolina
USAID
Viamo
WCEA

Appendix 2: Stakeholders Interview Guide

1. Can you share the specific projects you have been involved in that uses digital platforms to train health workers, such as community health workers, nurses, or midwives?
2. Who would you say is the “driving factor” behind the projects that you just described above?
3. Was any training conducted for the health workers of interest for them to learn and/or familiarize themselves with the digital platform?
4. What process did your team take for the content creation of the training?
5. Based on your experiences, what would you define as the minimum requirements for adaption of content onto a digital platform?
6. How did you assess training uptake among the health workers?
7. From these projects, would you say that training health workers using a digital learning platform is a feasible mechanism? What are your future takeaways?

Journal of Health Informatics in Africa

The Role of Telehealth in Response to Disaster Related Emergencies

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Abstract. In recent years, the world has seen a sharp increase in the frequency and severity of natural disasters which have caused immense damage to the ecological environment, loss of life, and deterioration of health and health services [1]. Concurrently, the use of mobile technology to support long distance access to care and deliver health information and services has increased [1]. Consequently, the exploration and utilization of telehealth solutions to addressing the emergencies and health challenges that result from these man-made or natural disasters has become a crucial component in disaster response. This article seeks to highlight how telehealth solutions are being used in disaster emergency response, using Chipatala Cha Pa Foni (CCPF), a national-scale telehealth solution in Malawi, as a case study. CCPF, which is modelled on the Health Center by Phone (HCBP) solution, was leveraged to respond to the recent devastating impact of Cyclone Freddy. During the Cyclone and the weeks that followed, CCPF facilitated access to timely health information, emergency medical services and access to rescue referral services. This experience shows how telehealth can and has shown to strengthen disaster emergency response by facilitating access to essential health care and life-saving services. This is more so when factors such as leveraging of key partnerships, human resource capacity and meaningful data use are considered.

Keywords: Telehealth, Health Centre by Phone, Chipatala Cha Pa Foni, Disasters emergency, Cyclone Freddy, Malawi.

1 Background

1.1 Tropical Cyclones and their effect on health

A tropical cyclone is a large-scale low-pressure weather system that forms over tropical or subtropical waters that are characterised by strong rotating winds and organised thunderstorm activity[2]. Tropical cyclones, otherwise known as Typhoons or hurricanes, are one of the most destructive climate related phenomena[3]. The intense circular storms, which cause torrential rainfall and strong winds, resulting in flooding and mudslides can cause significant loss of life, physical injuries and displacement of people [4]. The occurrence of tropical cyclones can also have an indirect impact on health care access and provision. This impact includes damage to health facilities, damage to road infrastructure, inadequate access to water, sanitation facilities and safe shelter [5]. Further, in addition to disrupting essential care, Tropical cyclones have also been connected to the increase of infectious diseases and the occurrence of outbreaks such as Cholera [6] and in cases where the outbreaks already existed, exacerbating them [7]. For instance, during the COVID-19 pandemic, the Philippines was impacted by 22 tropical cyclones resulting, among other effects, increased COVID-19 cases due to overcrowding in evacuation centres and an increased need for psychosocial support [7].

1.2 Cyclone Freddy

The tropical storm Cyclone Freddy formed over the Indian ocean in February 2023[8]. Lasting for over a month, the cyclone made its way through to southern Africa, impacting Madagascar, Mozambique and finally Malawi. In Malawi, Cyclone Freddy caused torrential rainfall, resulting in flooding and destructive

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mudslides, impacting 14 districts in the southern part of the country. Amongst the 14 districts that were affected, Blantyre, Nsanje, Phalombe, Mulanje and Chikwawa were the worst affected. A flash update by OCHA showed that, within **3** days, approximately **511** people had lost their lives, **533** were missing and about **567,239** had been displaced as a result of the effects of the cyclone. Following a declaration of a state of emergency in the 14 affected districts and the setting up of an Emergency Operations Center (EOC) the Government of Malawi with support from development partners implemented emergency response interventions including, search and rescue, humanitarian as well as relief interventions [9].

2 Method/ Intervention

2.1 Chipatala Cha Pa Foni (CCPF)

Chipatala Cha Pa Foni (CCPF) is a toll-free national hotline and messaging service modelled on the Health Centre by Phone solution, that was first co-developed in 2011 by VillageReach and the Malawi Ministry of Health (MOH) to help communities make informed health decisions with consistent access to health information. The hotline, which is staffed by trained health workers, has evolved to provide multi-topic health information and referrals through multiple channels over the phone, including voice, Interactive Voice Recording (IVR), SMS, USSD and WhatsApp chatbot. Recent national and district level health emergencies, including COVID-19, typhoid and cholera, accelerated the addition of some of these features to strengthen the platform's utility for emergency response.

During December 2019, the service underwent a formal transfer of ownership to the Government, becoming an integral part of the Ministry of Health's service provision. In that same year, the service was merged with an emergency medical services (EMS) system, expanding its capabilities to include emergency medical assistance alongside its existing health information and referral services. Furthermore, a new feature was tested to facilitate easy access to COVID-19 information and monitor the spread of vaccine rumours.

An impact evaluation in 2018 showed that the health hotline was significantly tied to improved health knowledge and health-seeking behaviour within target communities was attributable to the use of the health hotline [10]. The evaluation showed links to cases of improved knowledge with regards to nutrition, maternal health and reproductive health among adolescents [10].

3 Results

3.1 CCPF response

During the cyclone and its aftermath, the CCPF platform played a crucial role in both addressing cyclone-related emergencies and contributing to the official response. In addition to the provision of health information, CCPF's referral and emergency service was able to facilitate the provision of first aid emergency care for victims and support for frontline rescue teams within the districts to identify victims and other areas that had been impacted by the cyclone. Between 13th and 15th March 2023, the Hotline received a total of 7,789 calls. Out of these, 17.20% (3,875) reported flooding, 6% (1,484) reported incidents of drowning, 5.20% (1,182) reported the collapsing of a building, 3.90% (891) reported fatalities and 2.7% (608) reported missing persons. CCPF was used to coordinate rescue efforts that resulted in improved response times for emergency.

The devastating impact of losing one or more family members, property loss and sudden displacement and the inability to locate other family members during and after the cyclone brought an increased need for psychosocial support. Callers seeking psychosocial support included both the direct victims of the cyclone and from family members in other districts that were concerned for their family members in the impacted districts.

In the follow up weeks, VillageReach will further support the Government in strengthening the platforms ability to respond to both health emergencies and climate change induced disaster related health emergencies.

4 Discussion and Lessons learned

The data and experiences shared indicate that CCPF contributed towards access to essential health information and emergency medical services within the national response to Cyclone Freddy in Malawi.

Among the factors that facilitated this was radical leveraging of partnerships and collaboration. For instance, to adequately responding to the nuanced needs that emerged during cyclone Freddy, the Malawi MOH leveraged its existing and new partnerships to enable access to essential emergency services. This is highlighted as the hotline was able to connect callers to frontline responders such as medical personnel, Red Cross and the police. Although its contribution is apparent, challenges such as the inadequate human resource capacity at the hotline, the minimal monitoring and timely use of data and speed at which the hotline was adapted to respond to emerging needs affected its ability to more adequately contribute towards the disaster response. Consideration of these factors is essential in examining how the platform and others like it can further be strengthened to support future disaster related emergencies.

The health risks that result from natural and climate induced disasters are complex, far reaching and multifaceted. Therefore, addressing them requires urgent, multifaceted and innovative approaches to ensure minimal loss of life, reduction of casualties and other impacts on health both short and long term. All actors must be involved including policy makers, health care workers and communities but as this article further posits, telehealth solutions, with consideration to the key factors highlighted, can play a crucial role in disaster related health emergency response.

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Journal of Health Informatics in Africa

Journey towards a National Health Data Dictionary in Kenya

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Background and Purpose: A National Health Data Dictionary (NHDD) represents the set of nationally endorsed reference terminology standards and country-specific codes that can support collection, sharing, and analysis of health data. However, the path toward establishing an NHDD remains unclear. Kenya is keen to establish a robust Digital Health Platform that includes reference standards, one of which is a Terminology Service. Kenya is progressing toward establishing an NHDD by focusing primarily on terminology tooling, governance and policy, and capacity building. Establishing a technical use case that demonstrates small-scale success with the NHDD will help to learn about and expand Kenya's NHDD.
Methods: Under Ministry of Health leadership, Kenya conducted activities including stakeholder mapping, comparative analysis of terminology service tooling, deployment of an initial NHDD on the selected terminology service, and establishing working groups. Next, initiating a meaningful use case to test out NHDD workflows is necessary.
Results: Kenya gathered stakeholders and selected Open Concept Lab as the NHDD's terminology service. This software was deployed on local servers and loaded with reference terminologies and an initial set of NHDD content seeded from CIEL and updated to include local sources. Frameworks were drafted to guide working groups, which will help guide technical workflows for immediate future implementation.
Conclusions: Expanding an NHDD past the early stages to truly begin integrating or aligning health systems with NHDD standards is a challenging yet unclear undertaking. Although initial efforts can be completed, the demonstration of success and practical learning when testing a technical use case can further help align stakeholders by demonstrating positive outcomes related to the exchange of standardized health data. This work should inform roadmaps and toolkits to guide other countries in their own NHDD journeys.

Keywords: Terminology, NHDD, Health Information Interoperability, Health Policy

1 Introduction

With many digital health solutions currently in use globally and within countries, interoperability across these solutions is key for efficient data exchange. What's stopping us from achieving interoperability? We often ask ourselves this question, especially given the technology and standards that are available today. While there are many challenges involved in answering this question, one in particular is the need for alignment on the semantics of data that is sent or retrieved. This "semantic interoperability" is more than a technical question, however. It is more correct to attribute this as a governance and policy problem, not simply as a technical or organizational problem [1].

Despite the multitude of initiatives, both technical and non-technical, aimed at achieving data exchange and interoperability in low- and middle-income countries (LMICs), the adoption of standards in electronic health information systems continues to be a journey that is challenging and unclear for implementers. Even within individual countries, it is difficult to achieve alignment across the various systems, stakeholders, and health domains. The requirement for governance and guidance that can help to normalize clinical data can pave the way for the occurrence of consistent aggregation, reporting, data submission, and more.

As such, National Health Data Dictionaries (NHDDs) are an emerging topic in the global health space. An NHDD is a standardized vocabulary or set of terminologies that defines the data elements used in a country's

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healthcare system. It provides a common language and framework for exchanging and sharing health information between different healthcare providers, facilities, and systems. An NHDD serves as a foundation for electronic medical record (EMR) implementations and other health information systems, ensuring that data is collected and exchanged in a consistent and standardized manner across the country. This allows for better continuity of care, more accurate data analysis and reporting, and improved health outcomes overall. An NHDD is typically developed, published, and maintained by a national health authority or other relevant governing body. It may include a variety of data elements like patient demographics, diagnoses, procedures, medications, lab results, and more. The NHDD is typically based on international terminology standards, but may also include local variations or extensions specific to a particular country's healthcare system. Examples of reference terminologies and their scopes include:

- ICD-10 (International Classification of Diseases - 10th edition) - causes, complications, detailed anatomical location, severity, and diagnostic coding
- ICD-11 (International Classification of Diseases - 11th edition) - diseases, disorders, injuries, and causes of death
- SNOMED-CT (Systemized Nomenclature of Medicine – Clinical Terms) - symptoms, clinical findings, treatments, conditions, drugs, equipment, and more
- LOINC (Logical Observation Identifiers Names and Codes) - lab tests and clinical findings
- CIEL (Columbia International eHealth Laboratory) - Interface-friendly codes for diseases, treatments, drugs, and more

Overall, the NHDD plays a critical role in establishing a national health information architecture that supports the collection, sharing, and analysis of health data across different systems and stakeholders, ultimately leading to better healthcare delivery and outcomes. While some examples of NHDDs exist, such as Australia [2] and Turkey [3], there is not a clear path to guide countries in establishing an NHDD.

1.1 Progressing toward a Kenya NHDD

In recent years, Kenya has made significant progress toward its goal of having a Digital Health Platform as an ecosystem for health data collection, interchange, transmission and reporting based on standards. The country has emerged as a leader in developing an NHDD within an LMIC, with other countries like Nigeria, Ethiopia, Uganda, Sri Lanka, and others aiming to learn from their example. Beginning with efforts to align the collection of health data across their multiple implementations of OpenMRS, including KenyaEMR and AMPATH OpenMRS, the start of an NHDD was established using an adaptation of the CIEL Interface Terminology and deploying the Open Concept Lab (OCL) terminology service. This effort aimed to expand NHDD management outside of OpenMRS developers for the creation of a responsive and relevant set of terminology concepts that can be used to standardize data submission, collection, and more.

This progression, however, revealed many other requirements for making the NHDD successful in terms of country-wide use. To encourage uptake and meaningful use of the NHDD, simply deploying a concept dictionary on a terminology server is not enough. There were particular challenges for scaling the NHDD past the initial phase, mainly caused by Kenya’s political transition. With new Government staff at MOH now settled into their new roles, it is anticipated that the utilization of the NHDD will increase exponentially. As such, Kenya will require governance, transparent and responsive processes, training, and more if the NHDD is to be taken up by in-country implementers, health system managers, etc.

To kick off the scale-up phase of NHDD implementation, there is a need for a well-defined technical use case. Kenya has prioritized the Universal Health Coverage (UHC) as the primary use case that will drive utilization and generate value for that investment. Executing an example of this use case in a technical fashion will enable key learning that will support Kenya in its goals with the NHDD. The next step requires a display of technical success with the NHDD, using relevant terminology content and a meaningful outcome. This should adhere to the UHC use case where possible and should be agnostic to the medical records systems in use and health domain of the implementer.

This paper will give insight into the progress in Kenya for carrying out this technical use case and for establishing the tooling, governance, and capacity building work that will enable sustained success with the Kenya NHDD. We will answer the following questions:

- What efforts in the technical working groups have been most vital for progressing the NHDD?
- What is an example of a meaningful technical use case that can demonstrate technical success (e.g. data exchange or submission to a national data warehouse) with an NHDD?
- What in-country structures are required for success in establishing and uptaking an NHDD?

2 Materials and methods

With guidance from experts of terminology implementation in LMICs at the Regenstrief Institute (funded by PATH as part of the CDC Technical Assistance Platform initiative), Kenya performed the following activities:

1. Stakeholder mapping and engagement: In-country stakeholders were identified, mapped with respect to their relationships and proposed responsibilities, and engaged as part of the NHDD initiative.

2. Critical comparative analysis of candidate terminology services: To identify the most appropriate terminology service to host the NHDD's terminology content, the project conducted a comparative analysis between products that included open source softwares and their underlying technology solutions.

3. Deployment of the NHDD on a terminology service: Using the selected terminology service, an initial set of NHDD content was deployed on a local server owned by the Kenyan Ministry of Health (MOH). Additionally, reference terminology content was loaded as needed for mappings and subsetting as part of the NHDD.

4. Establishment of Working Groups (WG): Multiple working groups were set up to carry out the necessary NHDD activities, including the following groups:
   - *Capacity Building*: Sets up relevant NHDD training on the MOH Virtual Academy.
   - *Governance*: Establishes and executes processes for the management and uptake of the NHDD while being responsive to user needs.
   - *Tooling*: Sets up and maintains technology solutions for the NHDD, namely the selected terminology service.
   - *Monitoring and Evaluation (M&E)*: Establishes project metrics and ensures compliance to project goals.

5. Use Case Establishment and Workflow Testing: Selecting and carrying out a small but meaningful use case is a practical early step that helps to elucidate the challenges and test out the theories and frameworks developed in the Working Groups.

3 Results

Stakeholder mapping was performed and articulated, establishing a baseline set of stakeholders and roles relevant to the NHDD. These stakeholders were gathered under the guidance of Kenya's MOH, conveying the vision and value of aligning on an NHDD. This process helped to establish ownership over the key aspects of NHDD setup and maintenance, including the software, content, and policy and governance.

As part of this initial MOH-driven workshop, the comparative analysis of software solutions for terminology management was conducted, yielding the open-source, globally-focused terminology service called Open Concept Lab (OCL) as the selected platform. The curators of OCL provided training workshops in Mombasa, Kenya, in March 2023 to introduce key concepts and best practices with terminology management.

Following the software selection, the OCL software was deployed on Kenyan MOH servers. This enabled the importing of initial NHDD content, which was an adaptation of the CIEL Interface Terminology.

Additionally, this software environment was used as a home for reference terminology content that will later feed into the NHDD, as needed, during expansion. Reference terminologies imported include ICD-10, ICD-11, and CIEL. Additional Kenya-specific terminology content also continues to be explored and loaded, including a facility list, lab supplies, and medicines. The initial set of NHDD content launched at https://nhdd.health.go.ke/#/.

The established working groups also created materials and prepared for the scale-up, maintenance, and expansion of the NHDD. Each group has drafted and aims to finalize frameworks that drive the various aspects of the NHDD. For more information about these materials, contact the University of Nairobi at fnjiri@uonbi.ac.ke. These frameworks will undergo testing using a subset of NHDD content, multiple health domains, and more than one distinct health information system to test the ability to communicate and integrate with the NHDD.

4 Discussion

This work in progress aims to develop, publish, and maintain a nationally harmonized concept dictionary for local EMR implementations that will serve as the foundation for an emerging NHDD that enables a variety of data exchange needs within Kenya's health information architecture.

Managing curated health content through a terminology service approach requires competent, efficient, and effective technical assistance. The Regenstrief Institute provided the required technical assistance to Kenya's MOH and its partners that resulted in the establishment of the first ever national terminology service in Kenya, and within record time. With the initial setup of the NHDD, the Regenstrief team will continue to provide guidance for a set of technical individuals across multiple organizations in the establishment and execution of the technical use case. This will help to guide the future governance processes and capacity building materials, and will later unblock further technical discussions and help to engage other stakeholders.

Further expansion of the NHDD will also be a particular challenge, given the variety that comes with different health domains and the numerous existing health systems, such as medical records, lab information systems, and more. Finding domains and systems in which the NHDD can integrate will be necessary to ensure broad reach and uptake across Kenya.

Although the NHDD is still in its early stages, Kenya continues to be a driving leader in the nascent space of NHDDs, which will help to enable meaningful data exchange and interoperability for healthcare information. It is recommended that the processes and lessons learned from Kenya's NHDD establishment are well documented and shared with other countries that also aim to align in-country health data. The global health space also lacks educational materials on the meaning, value, and practical steps of starting up and maintaining an NHDD. Ideally, there will be a sandbox where newer implementers can test their alignment with an NHDD or even to receive guidance on how to get started and curate quality NHDD content for use in their country or use case.

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Implementation of Research Electronic Data Capture (REDCap)-based HIV Case Reporting System: A Multi-site and Multi-tier Approach Employed in Ethiopia

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Background and Purpose: The Ethiopian Public Health Institute (EPHI) began implementing HIV case-based reporting (CBR) on newly diagnosed HIV patients in June 2019, to monitor the epidemic over time and generate evidence to direct the HIV program's initiatives and resource utilization. One of the objectives of the HIV CBR is to reduce duplicate records by linking records from different health facilities for the same person.

The system collects information on newly diagnosed HIV-positive individuals at the point of care in health facilities using a paper-based form known as the Case Reporting Form (CRF). The collected data includes identifiers, demographics, clinical information, risk information, and Rapid Test for Recent Infection (RTRI)-testing. Secure information systems are expected to transfer this data from health facilities to EPHI. However, although available at health facilities, Electronic Medical Record (EMR), an electronic chronic HIV care monitoring system, can't securely transfer this data to EPHI because it's an offline system. As the EMR was not a viable option, the REDCap system was chosen to support HIV CBR in Ethiopia [1].

REDCap is a secure web application with an inbuilt data quality feature, used for building and managing online surveys and databases. This abstract summarizes how Ethiopia successfully implemented an on-premises REDCap-based HIV-CBR system in a phased manner.

Intervention: A REDCap instance was created and hosted on a physical server, virtualized onto a database and web servers, which were configured with static IP addresses and linked to the EPHI domain (Figure 1). We maximized data security by implementing a secure socket layer SSL and used a variety of functionalities, such as user rights, Data Access Group (DAG), custom report, and a REDCap hook (an approach for one piece of code to interact with another piece of code). A REDCap hook is implemented to hide/unhide the record status dashboard, which displays a list of all existing records/responses. A custom report feature is used to limit the subnational users to accessing only the de-identified data below their structure. Over 1,000 users were assigned different roles and DAG were implemented at each health facility to ensure entered data are not seen at another site. Over 1,000 individuals were trained on how to use REDCap specific to their role. The training, as well as the implementation at the site level, was done in stages, beginning with a small number of health facilities, and progressing to the target in a matter of months.

Results: As of March 2023, Ethiopia has successfully implemented a multi-site REDCap-based HIV CBR in more than 700 high volume public and private health facilities providing HIV services across 503 woredas (districts), 123 zones, and 13 regions. A total of 67,192 CBRs of newly diagnosed individuals were entered into REDCap by the health facilities between June 1, 2019, and Feb 28, 2023.

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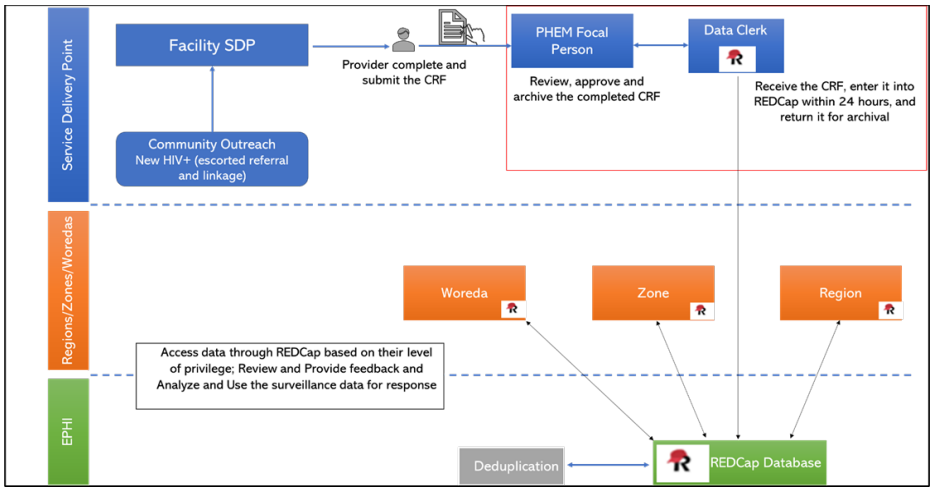
Lessons learned: A web-based REDCap system can be used in multi-site and multi-tier settings in resource-constrained environments where an EMR is not widely available to serve as a surveillance data source, or while data exchange between existing EMR and central database is being established. REDCap has also been used to enhance data quality by checking for data anomalies in real time using pre-defined and custom-built rules. CBR can be started on a small-scale using paper-based records from sites and be scaled up in a phased manner to web-based system covering large number of sites and health administration tiers. Since REDCap supports various data export and extraction mechanisms, data can be exported and transferred to another software to de-duplicate and match records using algorithms derived from multiple client identifiers, as well as for data analysis and visualization.



CRF: Case Reporting Form; SDP: Service delivery point

Figure 1. Diagram of data flow from health facilities to the Ethiopian Public Health Institute

Keywords: Case base reporting, REDCap, Multi-site, Multi-tier, Ethiopia.

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Journal of Health Informatics in Africa

Electronic Medical Record System Enabled HIV Program Data-driven Decision Making in Ethiopia

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Introduction: The Joint United Nations Program on HIV/AIDS (UNAIDS) 95-95-95 targets aim to diagnose 95% of all HIV-positive individuals, provide antiretroviral therapy for 95% of those diagnosed, and achieve viral suppression for 95% of those treated by 2025. Ethiopia is among the countries that adopted the UNAIDS 95-95-95 targets [1]. The country has over 450,000 patients being cared for in 1,100 clinics who are on anti-retroviral therapy (ART). These patients are retained in care and treatment at public, private, and non-governmental health facilities. We present here the EMR-ART system used in Ethiopia and its role in ensuring the quality of HIV patient care and data-driven decision making.

Methods: The monitoring and evaluation of HIV program implementation in Ethiopia is led by the Ministry of Health (MoH) and is integrated with the national health management information system (HMIS). The MoH initiated the deployment of the EMR ART system in 2018 at 112 health facilities providing HIV testing and ART services. This was scaled up to 715 health facilities with a minimum of 100 registered patients (65% of ART sites in the country) which were in-charge of over 350,000 records of patients on ART by September 2022. We provided training and on-site support in the twelve regions of Ethiopia on the decision-making support tools, reporting capability of the EMR-ART system, and on how the data can be used for clinical and programmatic purposes. The system was deployed at health facility level and ART clinicians and data managers entered the data into the system. Based on the requirements gathered from clinicians and the HIV program teams, the EMR-ART system was enhanced to serve as a data source for clinical and programmatic decision making at the health facility, woreda (district), region, and national level. The EMR-ART data was used in HIV program performance monthly reviews at region, sub-region, and health facility levels. The enhanced system has an inbuilt dashboard, line list analysis, alert features, and aggregate report generation capability that address the data analytics and report generations needs of the program.

Results: The different features of EMR-ART system in data analytics and data-driven decision making are summarized below (Table 1).

Table 1: Different features and functions of Ethiopia EMR ART for clinical management and care of HIV patients

Patient care and follow-up in facility and community
• The EMR-ART system generates the list of patients who have appointments on specific days and the clinicians will review patient records ahead of the patient visit. • The viral load (VL) result is automatically delivered to EMR ART and the clinicians will be able to provide timely care for patients with high viral load. • The EMR-ART system generates a line list of missed appointments and those lost to follow up, which is given to community partners for tracing and bringing back patients to care.
Clinical decision making
• The clinician can review the patient past clinical, laboratory, adherence status and regimen information during each follow up visit, facilitating clinical decision making.

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• The EMR-ART system alerts the clinician about patients who are eligible for TB preventive therapy (TPT) and VL testing. • The EMR-ART data is used to identify patients with advanced HIV disease and make appropriate clinical decisions.
Data reporting to facilitate programmatic decision-making
• The dashboard on the EMR-ART is used by health facility staff to understand patient status, and performance monitoring and planning purposes. • The EMR-ART system has an inbuilt data quality checking system, lessoning errors to enable sound data-driven for decision making. • The system can generate aggregate reports as per the MOH HMIS and PEPFAR Data for Accountability, Transparency and Impact Monitoring (DATIM) reporting requirement, which improves the quality of reporting. • The EMR custom analysis feature enables generating reports on the status of program achievement in terms of regimen, multi-month dispensing, cervical cancer service, and TB preventive therapy. • The EMR-ART data is extracted on a monthly basis (exportable data) and the data is analyzed for monthly monitoring of health facility and regional performance in multi-month dispensing (MMD), ARV regimen, TB Preventive Therapy (TPT) and cervical cancer activities. • The EMR ART data is used as a primary data source in the ARV drug demand forecasting and procurement at national level.

EMR-ART data is extracted monthly and analyzed from 351 health facilities in 10 regions (phase-1 facilities for the extraction) which is reviewed by HIV program team at national and regional levels. The case managers at health facilities in 715 health facilities use the line-list of appointed patients over the week to prepare patient charts and identify cases that are eligible for specialized care. Health facilities use the EMR to generate the list of patients who interrupted treatment beyond 30 days and provide the list to the designated community partners that use different approaches in bringing the patients back to treatment. The clinicians have been using the EMR ART to identify patients eligible for viral load testing as well as TB preventive therapy. The EMR ART has been generating a monthly report on the number of patients currently taking third line ART regimen which is approved by MOH as a reliable and up-to-date data for reporting and planning purposes.

Conclusions: The inclusion of information generation and in-built decision-making support tools in the EMR-ART system enabled use of patient level data for clinical and programmatic decision making. The health facilities and HIV program team demonstrated consistent use of the EMR-ART data in HIV program performance reviews. A forthcoming evaluation of the usability of the decision-making support tools from the perspective of the users is paramount to understanding the user satisfaction, practical feasibility and further enhance the system.

Keywords: Electronic medical record, patient care, data use, decision making, Ethiopia

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Experience in Electronic Medical Record System Transition from a Legacy Platform to Open-source Solution in Ethiopia

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Introduction: SmartCare was developed to meet the needs of the Zambia Ministry of Health in the care of HIV patients. The system uses enterprise Microsoft platform: C# and Dot Net Framework, and MS SQL database. SmartCare EMR-ART (anti-retroviral treatment) is a legacy desktop solution which was originally designed to be modular, easy to expand and capable of operating in limited resource environments using innovative technologies including Biometric Scanner, Smart Card, touch screen, wireless network, transport databases and role-based security. The application is capable of working in both network and in standalone mode. Significant improvements have been made to SmartCare in Ethiopia by adding more features and functionalities that include decision making support tools, reporting capabilities and enabling data exchange with laboratory information systems. The SmartCare EMR-ART was adapted in Ethiopia to support clinical care and data management at the ART clinics. Currently, it is implemented at more than 715 health facility ART clinics (65%) in Ethiopia involving over 350,000 patient records to support clinical care, HIV program monitoring and decision making through data use at all levels. The SmartCare EMR-ART has met the immediate needs of the country, but there have been challenges related with software customization, deployment, data extraction and interoperability with other systems. Based on the direction of the MoH, we have worked to transition from SmartCare to OpenMRS platform since May 2022 as per the national Electronic Health Record (EHR) standard [1]. We present the procedures and approaches used in the transition and describe the progress to date.

Methods: The transition plan to open-source platform used the experience of the SmartCare EMR-ART implementation as a foundation in defining the functional and non-functional requirements, workflow, human resource need, and infrastructure support. We enriched the existing requirement gathering and analysis with new requirements gathered at a weekly stakeholders' requirement review meeting and the feedback provided by SmartCare EMR-ART users. The requirement review meeting was conducted for two consecutive months till the need of the HIV clinical and program team is exhaustively captured. The software developers and requirement engineers led the discussions and captured the findings using a structured tool in a word processor. PEPFAR has been working on OpenMRS HIV Reference Implementation (OHRI) since 2020 to develop a generic solution for HIV related EMR modules for adaptation by any PEPFAR-supported country. Ethiopia decided to leverage the generic OHRI module resource in building the EMR-ART system the country needs. We collaborated with the lead partner in OHRI development and organized a two-week OHRI-focused hackathon in May 2022 involving a team of digital health leaders, software developers, software deployers, requirement engineers and business analysts from Ethiopia. A hackathon is an event where programmers get together for a short period of time to collaborate on a project. The trainees were grouped into four tracks, which include frontend/software developers (5), business analysts (3), backend/deployment (2) and the leadership tracks (2) with specific responsibility for each group. The country team at the hackathon exercised OHRI software development, and prepared a detailed software development, testing and deployment plan.

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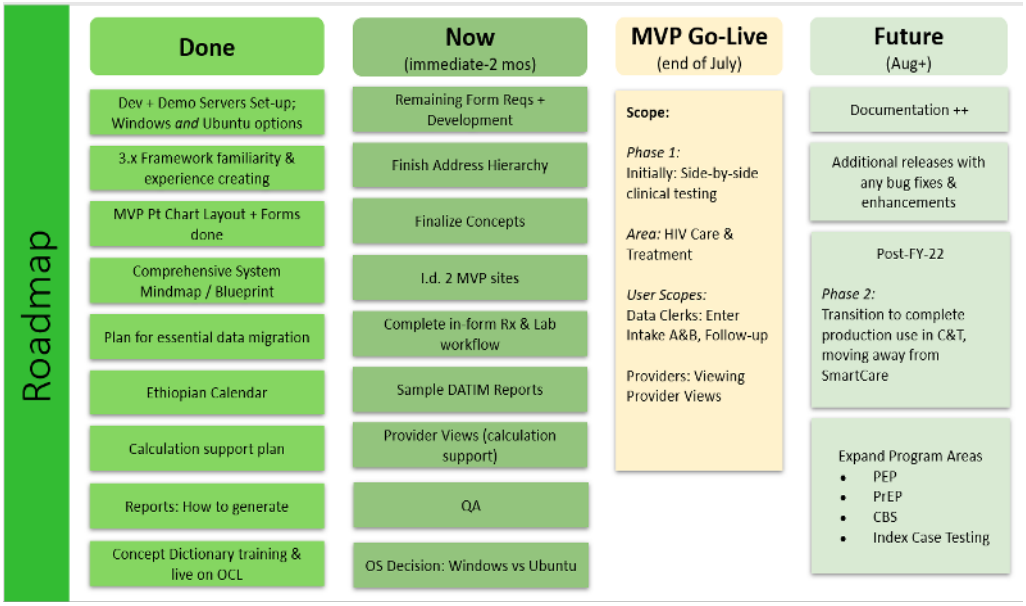
Results: The OHRI derived open-source EMR-ART adapted for Ethiopia is called "Ethiohri".
The functional and non-functional requirement for the Ethiohri was drafted before the hackathon and served as a resource in Ethiohri software development and testing during and after the hackathon. The first week hackathon also labelled as "Taking", focused on setting up each team with trainers and complete the 'low-hanging fruits' while the trainers observed and learned the practice. In the second week labelled as "Making", each team member was given focused deliverables using the framework for the stream-specific sessions. One explicit coach was assigned to the four tracks for coaching with emphasis on the key work needed for minimum viable product (MVP). The trainees became members of the global OpenMRS community [2], where the team could post any technical question or support on the platform and contribute to the global community.

During the two-week training, the trainees with the leadership of OHRI team achieved the following:

- Completed setting up development and Demo Servers.
- Explored the Windows and Ubuntu options for the system and were able to run on Windows operating system.
- Testing docker for quick application scale up to multiple health facilities that will reduce the effort related to installations at each health facility minimizing the dependency of application on the infrastructure at the health facility.
- Familiarized and got experience in creating forms using OpenMRS 3.x. Framework and developed MVP Patient Chart Layout and Forms.
- Developed comprehensive system Mindmap / Blueprint.
- Developed mechanism and integrated Ethiopian Calendar into Ethiohri which was contributed to OpenMRS.
- Familiarized themselves on Concept Dictionary training and live on Open Concept Lab (OCL) and started and progressed well in creating OCL for Ethiohri.
- Developed plan for essential data migration using Fast Health Interoperability Resources (FHIR).
- Held discussion on supporting calculation concepts like body mass index (BMI) and agreed to pilot implementation with few data elements in collaboration with the lead OHRI partner.
- Introduced on the tool for data extraction transformation and loading using Mamba-Extract Transform Load (Mamba-ETL) that helps in developing and generating aggregate or custom reports.

The team came up with a roadmap for the remaining software development and testing activities to be conducted in the short term (Figure 1). The Ethiopian health informatics team completed the tasks related to form development (intake and follow-up), address hierarchy, finalizing concepts, calculation support, sample aggregate and DATIM reports. Currently, the MVP is developed, and field testing is underway in two health facilities in Addis Ababa as of September 2022. This MVP will go live for 3 months with initial approach of side-by-side clinical testing focusing on HIV Care and Treatment with Data Clerks entering data from clinical Intake Form A and B, and Follow-up forms.

Figure 1. Roadmap of Ethiohri implementation in Ethiopia



Conclusions: The experience in the implementation of the legacy SmartCare EMR-ART has been instrumental in the design, development, testing and future deployment of the Ethiohri. Building local team capacity in the OHRI platform and establishing community of practice with Open MRS community boosted the capacity of the in-country team who was able to finalize the MVP as planned. The in-country team was also able to contribute to the global OpenMRS community, which shows the importance of wider-scale skill transfer to countries and engaging them in the global community to contribute to the global digital health product. The SmartCare EMR-ART has a huge amount of patient data, and the data migration plan needs careful planning for seamless transition from the legacy platform to Ethiohri.

Keywords: Electronic medical record, open source, transition, Ethiopia

Reference:

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Journal of Health Informatics in Africa

OpenLMIS for Improving Health Commodities Tracking and Ensuring Availability: The Case of Malawi

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Background and Purpose: Receiving complete and timely orders from facilities posed a huge challenge in Malawi before the implementation of OpenLMIS. Due to this, data was only collected on a quarterly basis and facilities' reporting rate was very low. Thus, MOH implemented OpenLMIS, a web application to replace the old problematic system, improving data visibility, increasing the reporting frequency to monthly and improving the reporting rate. Due to the availability of up-to-date stock status information, health commodity tracking improved and thus availability of commodities increased, and stock-out rates minimized over time. This case study discusses the case of Malaria commodity tracking as an example and showcases the results achieved in improving commodity tracking and availability through the introduction of OpenLMIS.

Methods: OpenLMIS data collected from 2017 – 2022 was reviewed, trends of indicators related to facility reporting and stockout rates were analyzed and compared with data before the introduction of OpenLMIS to show the reduction in stockout rates and improvements in facility reporting rate. The stock status data from OpenLMIS was compared against the malaria cases reported through DHIS2 to illustrate decreases in the discrepancy ratio.

Results: The rollout of OpenLMIS to 400 facilities improved the quality of orders, completeness, timeliness and reported stock status information, resulting in improved on time and in full delivery of health commodities and ensuring higher availability and minimizing stock out rates significantly. For example, confirmed malaria diagnosis by mRDT increased from 67% in 2016 to 95% in 2022. Stock-out rates of first-line treatment of uncomplicated malaria remarkably reduced from over 10% in 2016 to less than 1% in 2022

Conclusions: The introduction of OpenLMIS improved data accuracy, timely reporting, and contributed to increased availability of commodities and continuity of health care provision for the citizens of Malawi.

Keywords: Logistics Management Information System, OpenLMIS, Malaria.

1 Introduction

Receiving complete and timely orders from facilities posed a huge challenge in Malawi before the implementation of OpenLMIS. Due to this, data was only collected on a quarterly basis and facilities' reporting rate was very low. . Thus, MOH implemented OpenLMIS, a web application to replace the old problematic system and improve data visibility, changed the reporting frequency to monthly, and improved the reporting rate. OpenLMIS is an open-source, web-enabled, enterprise-class electronic logistics management information system, purpose-built to manage medical commodity supply chains. Due to the availability of up-to-date stock status information, health commodities tracking improved, and stock-out rates were minimized over time. This case study discusses the case of Malaria commodity tracking as an example and showcases the results achieved in improving commodity tracking and availability through the introduction of OpenLMIS.

Before 2017, Malawi used a stand-alone logistics management information system (LMIS) tool for collecting and aggregating data from a limited number of facilities. However, sharing data with the MOH

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every quarter was a major challenge due to issues with the quality, completeness, and timeliness of data for the effective distribution of medical commodities for more than 670 health facilities in the country. Thus, recognizing the need for a robust national LMIS, the Ministry of Health conducted a detailed requirements workshop to lay the foundation for introducing and implementing an electronic LMIS system. The ministry benchmarked similar systems used by similar African countries and selected OpenLMIS as a viable solution to meet existing needs.

An efficient electronic LMIS system improves data quality, completeness, and timeliness of reports coming from facilities, and accommodates the programmatic needs of the MOH in terms of data accessibility and transparency. The system is easily configured and integrated with other supply chain and health information systems for effective data sharing and is a bridge for establishing the end-to-end visibility of health commodities in the supply chain.

Before the introduction of OpenLMIS, the Ministry of Health used three systems for health logistics systems reporting operations:

- A Microsoft Access based stand-alone tool for reporting.
- MS Excel for data aggregation, analysis, and report generation
- The CMST online tool for ordering

After the introduction of OpenLMIS, the three systems were consolidated into a single system, OpenLMIS, thus, reducing manual error, enabling quick and easy data access, and making better-informed decisions possible.

2 Materials and methods

OpenLMIS data collected from 2017 – 2022 was reviewed, trends of indicators related to facility reporting and stockout rates were analyzed and compared with data before the introduction of OpenLMIS to show the reduction in stockout rates and improvements in facility reporting rate. The stock status data from OpenLMIS was compared against the malaria cases reported through DHIS2 to illustrate decreases in the discrepancy ratio.

3 Results

Central managers from the MOH and process supervisors have seen a reduced workload, as their efforts have shifted from aggregating Microsoft Access files to focusing on data quality checks and trends analysis. These efficiencies have been further reinforced by the timeliness and completeness of reports. Reporting rates increased from an average of 30 percent to an average of more than 90% percent since the launch of OpenLMIS. Overtime, the OpenLMIS has been rolled out to 400 facilities as shown in Figure 1.

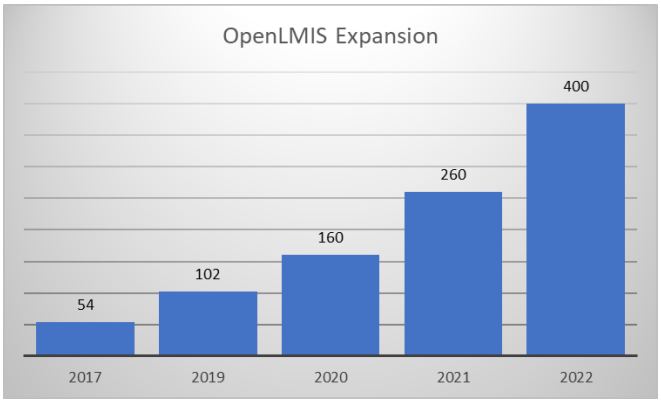

Figure 1- OpenLMIS expansion over time

OpenLMIS started with three programs to track; it expanded to track 10 programs currently, including COVD-19 PPE and vaccines. The OpenLMIS stock management module was used to implement the

vaccine tracking system where batch and expiry dates are tracked. This module has helped MOH in making efficient distribution decisions and in managing expiries of COVID-19 vaccines during the initial stages of the COVID-19 pandemic.

The implementation of OpenLMIS has significantly improved data availability and decision-making for the distribution of health commodities in Malawi. The system has enabled real-time tracking of stock levels and consumption rates, reduced the risk of stock-outs and overstocking in health facilities. The system has also improved the accuracy and timeliness of reporting, as illustrated in Figure 2, enabling health officials to make informed decisions about commodity distribution and allocation.

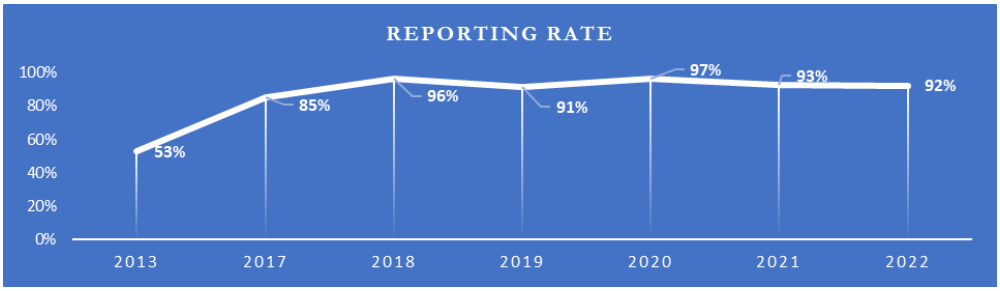

Figure 2 - Health Faciltities reporting rate (2013 - 2022)

As an example, the availability of data for supporting decision making about the demand identification and distribution planning has helped the country to significantly improve the capacity of hospitals and health centers for confirmed malaria diagnosis by mRDT, from 67% to 95% throughout the last national malaria strategic implementation period 2017-2022. Similarly, community health workers' capacity to diagnose malaria has improved from a baseline of 67% in 2016 to 100% in 2022. The implementation of OpenLMIS has contributed to a remarkable reduction in stock-out rates of first-line treatment of uncomplicated malaria from over 7% in 2016 to 0.3% in 2022. (Figure 3)

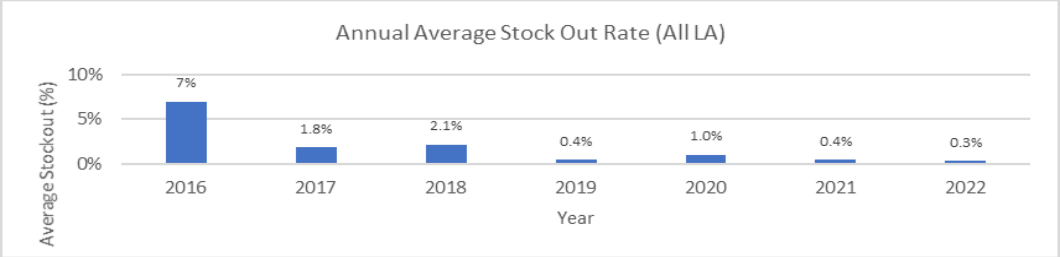

Figure 3 - Annual Average Stock Out Rate (2016-2022)

In addition, OpenLMIS has enhanced transparency and accountability in the supply chain by providing a comprehensive audit trail of commodity transactions. With the integration of OpenLMIS and DHIS-2, the availability of logistics data from OpenLMIS has helped to compare the discrepancy ratio against the malaria cases reported through DHIS2. For instance, the discrepancy ratio between the quantity of malaria first-line treatments issued (proxy for consumption) and the malaria cases reported decreased from 53% to 23% over the period of 8 years from 2018 - 2022 and availability of data contributed towards this reduction, as shown in Figure 4 below.

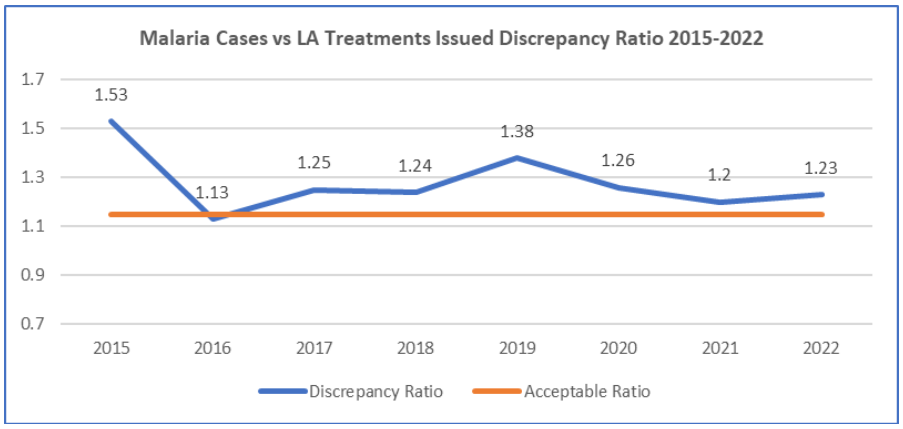

Figure 4 - Facility discrepancy ratio improvement (2013-2022)

4 Discussion

The continued system strengthening technical support on OpenLMIS to MOH has been instrumental in improving data recording, accuracy, and timely reporting, contributing to availability of data for decision making. This ensured sustained availability of commodities and continuity of health care provision to clients in Malawi. With the expansion of OpenLMIS, data is captured at the source in most facilities, minimizing transcription errors. In addition, the expiry projection report generated by the system has facilitated the MOH to minimize wastages and provided ground for evidence based annual quantifications and supply planning.

As observed by some users, “OpenLMIS is a user-friendly tool which helps operators swiftly manage their stock since it offers real-time data for action. When using paperwork, orders and approvals take time and by the time the ordered materials come, things have already changed on the ground. But with this tool, it gives you real-time data, and this is very exciting as users will be making decisions based on the actual situation on the ground at that time”, Thomas Nathan Luba, EPI Coordinator for Chiradzulu District Hospital.

The implementation of OpenLMIS demonstrates the potential of digital health interventions to improve health commodity supply chains in low-resource settings. The system has enabled informed decision-making, reduced stock-outs, and enhanced transparency and accountability. The success of this implementation provides valuable insights into scalable and sustainable digital health solutions that can be replicated in other settings.

Journal of Health Informatics in Africa

Improving Laboratory Services through Digitalization: Lessons from Zanzibar Laboratory Information System (ZanLIS)

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Background and Purpose
Laboratory investigation is very important in providing the right diagnosis and therefore providing quality health services, for clinicians to confirm the diagnosis for most of the conditions requiring laboratory investigations. In the implementation of the Zanzibar digital health strategy which emphasizes the digitalization of the health services, digitalization of the laboratory business process is very key in ensuring the services are improved at the health facility level and availability of quality data for informed decisions. PATH in collaboration with MOH Zanzibar through the support from CDC PEPFAR utilizes recommended digital principles to digitalize laboratory business processes in Zanzibar. There have been a lot of lessons learned during the digitization process that may be shared with digital health experts and learning from others who have gone through the same undertaking.

Methods
The project is planning to share the steps taken to digitalize the laboratory business process. The work was started by the tech teams to go through the literature review to understand what has been done and find out if there is any documentation that can help through the process. Different documentation informed the process in each stage of development as well as implementation.

Engaging the user and stakeholders at all levels in the documentation of the requirements using the Collaborative Requirement Gathering Methodology (CRDM)1 by the Public Health Informatics Institute. Engaging the end-user was key to ensuring the principle of digital development2 is followed. Requirement gathering step involved documentation of the current laboratory business processes for most of the health facilities. The technic used to collect and document the business process was through the drawing of the business process in groups and presentations, this methodology ensures good participation and easy understanding of the flow.

After drawing the business process maps of the current process followed by identification of the problem. Through this presentation, the pain points that were identified will be presented for participants to learn about the challenges that were encountered on the paper-based system setup and solutions to these problems informed the re-engineering of the business processes and digitalization of the processes. Most of the pain points were addressed by the digitalization of the business processes, for example, pain points related to the availability of quality data, and delay to receive results, especially for samples that are referred from one laboratory to another.

The documented business processes were validated by visiting the health facility and assessing the processes and how the re-engineered business process can be implemented. The aim is to access the feasibility of the to-be business processes before doing the actual digitalization. The process of validating the business process is very important to ensure the success of the digitalization process. The validation also involves checking the policies and guidelines which govern these processes to ensure what is developed does not go against the guidelines.

The user's requirements were documented based on the validated business process, the requirements are documented based on the business process and provided with the number that reflects the activities within

[1] Collaborative Requirements Development Methodology (CRDM) - PHII
[2] | Principles for Digital Development (digitalprinciples.org)

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the business process. The numbering is very important to ensure that whoever is developing those requirements can have a way to reference the process and ensure what is developed is in line with the business process mapped.

Through this presentation, we will share the process that we took to identify the platform that suits the documented requirements and business processes. Identified laboratory information systems that were reviewed against the documented requirements and selected one platform which was used to develop Zanzibar Laboratory Information System (ZanLIS).

Having a configurable system is very important for the successful implementation of the laboratory information system. In this presentation experience and lessons learned on the configurations and rollout stage of the system will be presented.

Conclusion

The participant will get an opportunity to learn and understand how Zanzibar approached the development of their own laboratory information system including the challenges that were encountered and the way they have addressed these challenges.

Keywords: Laboratory, Laboratory Information System, Zanzibar, Digital health strategy

Journal of Health Informatics in Africa

Impactful approach to identify national digital health investments for scale, with an aim towards sustainability

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1 Introduction

In order to achieve a positive impact on a country's health information systems ecosystem, investments need to be directed to impactful and sustainable digital heath solutions. For this reason it's important to carefully and strategically assess a country's HIS ecosystem to identify the right digital health investments. The Millennium Corporation Challenge (MCC) [1] identifies countries that have a healthy economic growth trajectory and invests in those countries' sectors that are driving the growth. In Lesotho, the information communications technology (ICT) and digital health have been identified as some of those key sectors, for MCC investment. In 2021, RTI International [2] and the National University of Lesotho (NUL) [3] worked alongside MCC, and the Lesotho Millennium Development Authority (LMDA) to plan an ICT assessment that would help identify key areas for scale in sectors driving technological growth, with the goal of identifying modern, effective digital health solutions for scale in a timely and cost-effective manner, and improving Lesotho's ICT connectivity, to improve service in the health sector. All findings and recommendations are documented in [4].

2 Materials and methods

Our ICT assessment started during the spur of the Covid19 pandemic. As a result, the methodology used to complete the ICT assessment required creative execution. With a nationally focused assessment, targeting the health sector, network coverage, and health information systems at the community, district, and national levels, our assessment included the following phases: 1) Literature review; 2) District site visits (assessments of district, health facilities, and community councils); 3) National office interviews (interviews with management and assessment of some national offices); and 4) Topical discussions (discussions around key topics with multiple identified stakeholders in Lesotho health and ICT).

The literature review served as a situation awareness exercise to understand the extent to which the government entities have contributed to the ICT and digital health investments in-country. It served as a basis to target relevant Government of Lesotho (GOL) entities and partners for further investigation into the use of, and investment, in ICT and technological solutions. Additionally, telecommunications and mobile network provider coverage maps provided insights into the level of mobile network coverage across each district, and future plans for the expansion of the Lesotho Government Data Network (LGDN) [4].

At the national level, the Ministry of Health (MOH) [5] was the entity of priority, alongside their implementing partners and donors (PEPFAR [6], Global Fund [7], and WHO [8]). Other government entities with key ICT investments and authority over components of the Lesotho ICT sector were also consulted, such as the Ministry of Communications, Science, and Technology [9], the Ministry of Home Affairs [10], and the Ministry of Agriculture [11]. Interviews were held with health management information systems, and the ICT team leads, along with the national laboratory and pharmacy focal points. Efforts were made to learn about existing HIS enterprise architecture; ICT expert support structures at the

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subnational level; LGDN; and digital health investments. The national electronic health records systems, laboratory information systems, and pharmaceutical systems were prioritized.

At the sub-national level, district health teams, community councils, and health facilities were prioritized. Not being able to venture into every district and every health facility in the country, and to be economical, while ensuring valid results, our sampling methodology directed us to focus on seven (7) out of the ten (10) districts in Lesotho. The selected districts represented urban and rural based health facilities, which characteristically tend to have a different concentration of human resource capacity, connectivity, and infrastructure. Consultations at the local level included an inventory of ICT equipments and digital health investments, assessment of network connectivity, and the determination of ICT support capacity. Exploration at the local level allowed us to interact with the Ministry of Local Government and Chieftainship [12] at the district and community levels, and this offered key insights into the planned expansion of ICT network support across the health system.

3 Results

Our overarching findings illustrated a plethora of opportunities to invest in the Lesotho ICT sector [4]. In particular, the findings indicated the key areas for investment to improve ICT infrastructure in support of expanding network accessibility, and where to prioritize optimization and scale of sustainable digital health solutions. Additionally, It was revealed that ICT infrastructure improvements also require tackling improvements to governance practices and policies, and ICT support and maintenance especially at the lowest level of the health system. Among others, expansion of network coverage, and scaling of national digital health global goods including the national electronic health record system, national health information system, pharmaceutical system, and general optimization of the national health information exchange (all key components of an HIS ecosystem) should be prioritized.

Also, it is important to ensure that where existing digital health implementations are successful, future investments must leverage and build on them, rather than create something new. This helps to ensure that resources are adequately used.

Additionally, it's important that local capacity is involved throughout planning and implementation, and the government leads the coordination of investments.

Lastly, all interventions should make a collective effort to engage existing donors and implementing partners, to ensure the adequate use and sharing of resources allocated to ICT infrastructure strengthening and digital health scale.

4 Discussion

An assessment approach involving an in-depth literature review, followed by interviews with key informants, and targeted site visits, offers a stepwise approach for a deep dive into understanding the state of ICT infrastructure, and HIS ecosystem in a country. Gaining situation awareness through a literature review offers a foundational understanding of the current state, and data from the literature review can be further validated by site visits and key informant interviews.

Additionally, a true appreciation of digital investments made across a government, and health system in particular, requires a holistic and targeted focus on key government stakeholders at both the national and local level, as well as input from implementing partners performing HIS strengthening and service providers leading network and general ICT expansion in a country.

A holistic and targeted approach to a digital health assessment is key to investing in sustainable digital health. Sustainability is an important agenda for developing countries that have limited resources and rely on foreign funding.

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Journal of Health Informatics in Africa

Designing an offline-first, mobile electronic medical record system for integrated antiretroviral therapy in Lilongwe, Malawi; the Community-based ART REtention and Suppression (CARES) App

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Background and Purpose: Digital health interventions are recognised as powerful tools that can empower healthcare workers (HCWs) to deliver quality services in the community whenever needed and at reduced costs. To develop desirable digital health interventions, it is important to involve HCWs in all aspects of the system development process. This can be achieved through the use of human centered design (HCD), an approach that ensures the inclusion of HCWs voices, prioritizes their needs and contextualizes digital tools. We sought to design and optimize an offline-first POC EMR system to support ART care delivery in the community.
Methods: Guided by a HCD framework with the following steps: discover & define, ideate & prototype and test & iterate, HCWs and decision markers were engaged during the design and evaluation of the mCARES system.
Results: User-informed requirements guided the development of a tool that supports the delivery of quality care by providing timely tasks and alerts for follow up, embedded logic ensures data quality, offers automation of records management and facilitates data exchange with the health facility EMR. Rapid testing of components with users informed the workflow re-designs and prototype iterations..
Conclusions: Co-creation of tools ensures that the right problems are solved and that users' needs are prioritized. Further testing and evaluations of the mCARES system in the community will provide data to inform workflow and app iterations. The HCD steps described will help guide the design, development and evaluation of future POC EMRs like systems.

Keywords: Human centered design, digital innovations, mobile electronic medical record systems, Malawi (style keywords)

1 Introduction

Expanding health services to the general population including vulnerable and marginalised communities could accelerate the attainment of universal health coverage [1]. Digital health interventions are recognised as powerful tools that can empower healthcare workers (HCWs) to deliver quality services in the community whenever needed and at reduced costs. To develop desirable digital health interventions, it is important to involve HCWs in all aspects of the system development process. This can be achieved through the use of human centered design (HCD), an approach that ensures the inclusion of HCWs voices, prioritizes their needs and contextualizes digital tools. HCD offers an opportunity for users and stakeholders to collaborate in designing around the contextual limitations and technological barriers. This collaborative

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co-design of digital tools also ensures effective implementation by fostering stakeholder buy-in and ownership, ultimately leading to sustainable long-term solutions.

The HCD process is cyclical and often features the following phases; discover & define, ideate & prototype and test & iterate. The discover and define phase seeks to examine, research and understand the problem and context, test assumptions, collaboratively identify the pain points to be solved and promote consensus building. A successful run of this phase culminates into a shared vision among all stakeholders, clearly articulated problems to be solved and an outline of the next steps. It is during the ideate and prototype phase that ideas are examined from different perspectives using prompts such as "*How might we*" statements. Generation of many ideas is encouraged at this stage inorder to increase the chances of uncovering the optimal design pathway. Ideas are then evaluated and critiqued by stakeholders and a list of proposed solutions produced at the end of the session. Proposed solutions are translated into simple, inexpensive sketches of the product or workflow to investigate the ideas generated. Ideas are mixed up, rejected or revised, until stakeholders identify optimal designs. The final designs define how the different elements will work together, how users would interact with the end product and the product limitations. The next phase entails testing the solution with end users in their context. Minimal guidance is provided during the testing runs and techniques such as the observation and measurements are employed to evaluate how users interact with the product. This process reveals problems with the products, opportunities for improvements and how end users think, behave and feel towards the product or workflows. It is not unusual for the team to revisit the earlier steps in case the solutions don't reflect end users' needs.

2 Materials and methods

2.1 Case study setting

Differentiated service delivery models (DSD), client-centered approaches that tailor HIV services for different groups across the cascade of care [2], seek to reduce patient, provider, and ART program burden by moving stable clients from crowded public clinics to communities for simplified, needs based [3], lower cost [4] care. In Malawi, Lighthouse Trust (LT), a WHO recognised Centre of Excellence, implements a DSD approach, the nurse-led community ART program (NCAP) specifically designed for stable ART clients [5]. In NCAP, nurses provide ART services to clients through peer support meetings in the community. LT employs a point-of-care (POC) EMRs at its static sites, not in the community, for ART care delivery and coordination and program outcomes tracking. Expansion of the NCAP program is proving difficult because of following challenges: first, the EMRs has only been deployed in technologically enabled clinics with consistent network and power, not in community settings where NCAP operates. Data is captured using an Open Data Kit (ODK) form on an android tablet during NCAP visits. It is then printed and manually entered into the EMR by clerks. Second, the manual data entry process is inefficient, incomplete, error-prone and may result in delays in the reconciliation of clients records. Lighthouse Trust (LT), International Training and Education Centre for Health (I-TECH) and Medic Mobile collaborated to co-design and develop a tablet-based, mobile, point of care EMRs App for NCAP: Community-based ART REtention and Suppression (mCARES), that will serve as an extension of the EMR at health facilities.

The CARES app has leveraged the open source community health toolkit (CHT) framework to build an offline first point of care (POC) EMRs [6].The CHT supports extensive customization and can be integrated with health information systems such as DHIS2 and OpenMRS. Digital health apps built using the Core Framework can support many languages, run offline-first, work with basic phones (via SMS), smartphones (Android App), tablets, and computers. The application supports configurable areas of functionality such as longitudinal person profiles, task and schedule management, decision support workflows, messaging, and analytics. Consequently, mCARES is built on the CHT core as an extension of the facility based EMR in order to maintain data integrity, familiarity, learnability and usability for the NCAP nurses.

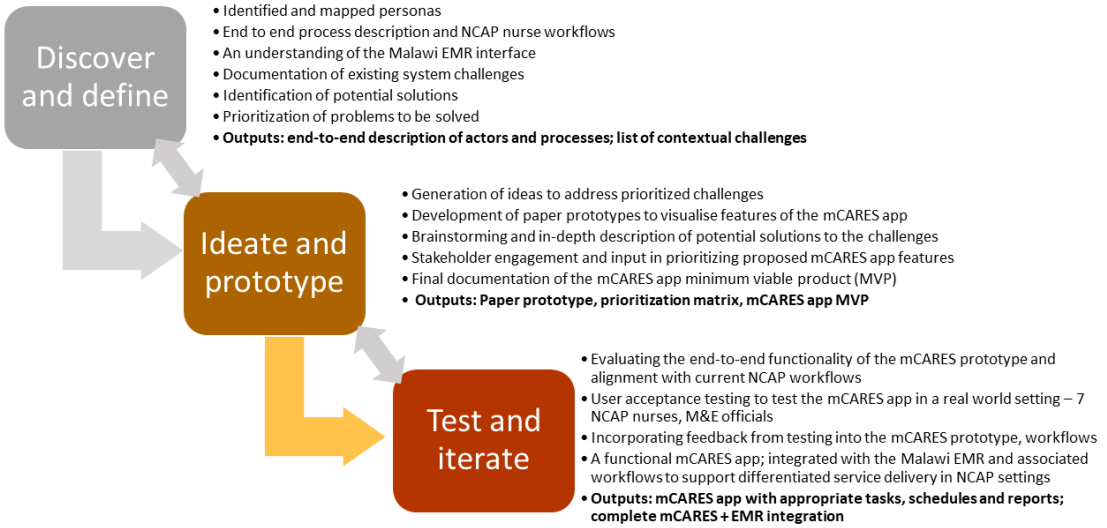
2.2 Application of the HCD framework

HCD approach was employed to guide the design and optimization of the platform. During the first phase (discover and define) in-depth conversations and groups discussions were conducted with LT monitoring and evaluation (M&E) staff, local EMR system experts including at LT and LT NCAP nurses at the flagship health facilities in Lilongwe and LT supported health facilities in urban and peri-urban parts of Lilongwe District. A review of the health facility EMR, paper-based data collection tools and the ODK based data entry platform was conducted to gain an understanding of the care coordination processes. The shadowing technique was employed to understand and define the end to end mapping of the NCAP nurses processes. Thereafter, weekly codesign meetings were held with NCAP nurses and data users pre the MVP (during the ideation and prototyping phase) and post the MVP (after the development of the first functional mCARES app) to evaluate and test the designs and developed prototype respectively.

3 Results

3.1 Discover and define

The NCAP nurses service delivery approach was defined, processes mapped and interactions with different personas described. Nurses meet peer support groups every 3 months; while clients from these groups meet one-on-one with NCAP nurses. Assessments are conducted for each patient during individual visits and data entered in a tablet using a data management Open Data Kit (ODK) form on an android tablet. Blood samples are drawn from patients whose annual viral load tests are due. After the community visits, nurses return to LT and print the ODK data for manual entry into EMRs by M&E Officers. It was reported that many ODK fields do not match with EMRs fields leading to data gaps in the EMR; slow patient tracing and continuity. Several other challenges were reported including siloed EMR systems which means that data exchange across facilities is largely manual. Figure 1 describes the HCD steps, process and outputs produced at each phase.

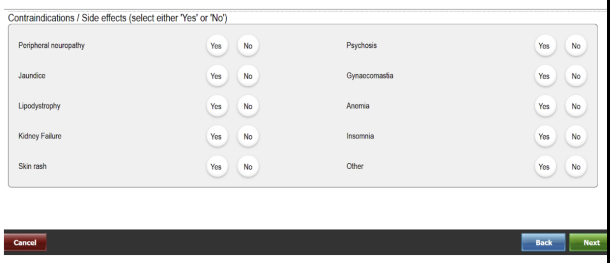
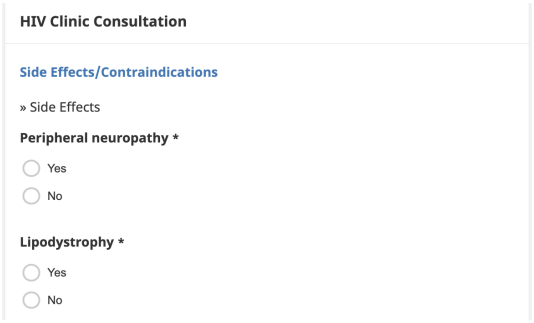


3.2 Ideate and prototype

On the basis of providing quality ART services in the community, four key considerations informed the development of a desirable tool. First, the mCARES app should extend and provide the EMR experience in the community by ensuring that all the EMR processes including NCAP registration, anthropometric measurements, viral load monitoring, ART clinical review, drug dispensing and automated appointment scheduling are accessed. Second, mCARES should aim to expand provider decision-making support tools (alerts and tasks based on client care inputs) to ensure that referrals, timely testing, and follow-up actions are not missed in NCAP settings. Third, the platform should allow offline data collection. Fourth, data exchange between the mCARES and the EMR should be enabled. Fourth, mCARES should aim to automate the NCAP manual tasks such as the retrieval of the list of clients with upcoming viral load test appointments and calculation of adherence rates. Prototypes were developed, iterated and the final designs documented inorder to guide the engineering process.

Figure 2: Final mCARES app design of the list of clients with missing or upcoming viral load tests appointments

Based on the above considerations, a simple version of the mCARES would be developed to support the core EMR POC functions within the structural confines of the CHT core framework. Incremental changes would be iteratively added to address the behaviors and interaction patterns of end users with mCARES. Figure 3 below outlines how the EMR experience is anticipated in the mCARES app.

Malawi EMR	mCARES app
 screening questions as they appear in the EMR	 proposed design of the screening questions in the mCARES app

3.3 Test and Iterate

Practical sessions were conducted with NCAP nurses and M&E clerks during the design and development phases to obtain feedback on the mCARES designs, workflows and the functional app. During the sessions, end users examined the CARES prototypes for fitness of purpose, compliance with the recommended guidelines and usability in the NCAP setting. A meeting with Ministry of Health (MoH) representatives was held to present process progress, solicit feedback and incorporate suggestions to ensure app co-creation with local and national policy-makers. The final minimum viable product (MVP) version of the mCARES App presented considerable logic updates, automation of NCAP manual tasks and alerts, workflow improvements and experiences compared to the original ODK tool that the NCAP nurses use. There was general consensus across the NCAP team that mCARES App provided for an improved ART workflow guide using tasks and alerts.

4 Discussion

The application of a HCD framework ensured that NCAP staff including nurses, data users and decision makers were involved in the co-creation process of the mCARES app. The co-design sessions enhanced the collaboration process, ensured that feedback was sought rapidly and continued alignment on the goals to be achieved, that is, to develop an offline-first POC EMR system for use in the community. Developing mCARES on an already existing tool has many benefits such as spending less time in the development process, building on a tool that can guarantee privacy, stability and efficiency in service delivery as the CHT has been deployed in other settings and scaled by national governments [6]. The development and implementation is in an MoH ART setting improving program scalability and sustainability. The application of the HCD process introduced challenges such as difficulties in aligning schedules for the co-design sessions, promoting buy-in of the process for those that were new to the HCD framework and target users desire to replicate the EMR user interface designs as is in mCARES. Some of the proposed mCARES features such as the hierarchy and data downloads were not easy to build in CHT which led to a re-design of the proposed solutions, workflows and changes in the technical approach. The development process took longer than expected due to the above mentioned complexities. In addition, as is with other technologies the review of digital health app interventions and approvals for data exchange with national systems such as the EMR takes a while as it involves comprehensive systems and process evaluations in order to ensure that the tools adhere to the regulatory guidelines and that client's data is preserved and secured. The next steps will entail launching of the mCARES App in NCAP settings following MoH approvals and usability testing post-implementation.

5 Conclusion

Co-creation of tools ensures that the right problems are solved and that users' needs are prioritized. It also saves on time, since feedback is regularly sought throughout the development process and ploughed back into the designs. The usability aspects are also explored with users to ensure that users behaviors and interactions with the tools are identified and addressed early. The design of additional mCARES features such as automation of the data extraction process and the non-communicable disease (NCD) management module is ongoing.

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Journal of Health Informatics in Africa

Scoping Study for Electronic Medical Certification of Cause of Death in South Africa

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1 Introduction

The South African Civil Registration and Vital Statistics system, while showing improvements, faces challenges in meeting public health surveillance needs due to its paper-based nature, manual cause of death coding, and quality of medical certification. To address this, we conducted a scoping study on electronic medical certification of the cause of death (eMCCD) to inform a transition to an electronic death registration system (EDRS).

2 Materials and methods

The study encompassed a literature review, a participatory webinar with EDRS-experienced individuals, a technical evaluation of South African mortality data systems, a feasibility and acceptability study among frontline users, and a review of potential legal hindrances.

3 Results

International experiences underscored EDRS benefits in enhancing data availability, timeliness, and quality of mortality statistics, contingent on strong leadership, supportive legislation, and stakeholder involvement. Challenges include legislative issues, user acceptability, and diverse electronic systems and infrastructure. The technical landscape evaluation revealed risks tied to equipment, electricity supply, and connectivity dependencies. The fragmented Health Information Systems (HIS) landscape suggests potential enrichment of data quality through integration of electronic medical records (EMRs) with eMCCD. Users found eMCCD acceptable and beneficial, emphasizing simplicity, accessibility, and integration with other systems. Legal opinions identified regulatory changes required to overcome barriers.

4 Conclusions

Implementing eMCCD appears strategic and feasible with careful planning. A comprehensive requirements gathering process involving all stakeholders, guided by global learnings and standards, is essential. Consideration for digital signing, user authentication, reliable connectivity, and secure data exchange is crucial, and organizational change management is pivotal for successful implementation.

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Journal of Health Informatics in Africa

Tracking Patients on ART with Malawi's Electronic Medical Records System

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1 Introduction

Over the last decade, electronic medical records system (EMRS) has been implemented and scaled nationwide with a coverage of 769 health care facilities reaching 915,233 people living with HIV (PLHIV) on antiretroviral treatment (ART) as at Q2 2022. This is the largest EMRS implementation in Malawi and is representative of 96% of PLHIV in Malawi. This information is published on the Malawi Analytics Platform. The EMRS has several modules used in real-time and retrospectively to ensure accurate and timely documentation for patient care, which enables reporting and tracking patients in care. Based on appointment reports generated during clinical care, EMRS users can identify missed appointments, which are then followed up. This analysis demonstrates how Malawi health professionals can utilize the EMRS to track PLHIV who are lost to follow up (LTFU) and who return to treatment.

2 Methods

Descriptive statistical analysis was applied to the EMRS data collected from October 2020−March 2022. We reviewed national quarterly trends of indicators related to patient retention, including: 1) the number of patients on ART LTFU (no clinical contact for > 28 days); and 2) the number of patients on ART who experienced interruption in treatment but successfully restarted ART.

3 Results

Between October 2020−June 2022, the number of patients on ART who were LTFU decreased from 44,501 to 23,744, representing a 42% decrease. Disaggregated data outcomes for patients LTFU show that the largest contributing factor is interruption in treatment, roughly 66%. While there was a 70% decrease from October 2020− June 2022 of clients returning to care after an interruption in treatment, an 11% increase was observed for clients alive and on ART between October 2020 to June 2022.

4 Conclusions

The national HIV EMRS has facilitated the efforts of health care staff to track and trace patients who had interruption in treatment, as seen through care retention indicators, and thus quality of care for PLHIV. The EMRS can flag reminders and generate lists of clients that need to be traced, easing follow up of clients with interruption in treatment. These system capabilities along with continued EMRS system use are improving patient tracking and retention. Future efforts include implementing a Back-2-Care application, which adds client-specific, community-level tracking to the current EMRS, allowing for improved patient retention.

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Journal of Health Informatics in Africa

Development of an Interactive Voice Response (Call for Life-PROVE) survey system for monitoring COVID-19 vaccination outcomes in Africa

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Background and Purpose: The monitoring of COVID-19 vaccination outcomes is essential for ensuring vaccine safety. However, traditional methods for vaccination monitoring often have shortfalls, such as poor data quality and delayed data availability. Interactive Voice Response (IVR) technology has many advantages over traditional methods as it collects real-time data and can reach a large population with minimal resources. We developed and tested an IVR system, Call for Life-PROVE (CFL-PROVE), to collect information on vaccination outcomes from participants in the Program for Research for Vaccine Effectiveness (PROVE), an implementation science program across 13 African countries.
Methods: We held requirements gathering meetings with the PROVE research team to establish the information required. The variables from requirements gathering were then used to develop the CFL-PROVE system. This was subjected to testing among PROVE program staff in Uganda and Malawi, who reviewed the calls and provided feedback. We assessed feasibility of CFL-PROVE through completeness (percentage of calls that had all questions answered) and quality (audibility) of calls.
Results: We evaluated 300 calls in total (160 in Uganda and 140 in Malawi), with a completion rate of 55% and 54% in Uganda and Malawi, respectively. While 89.8% of testers gave us positive feedback on call quality, 10.2% reported issues for example rushed-through questions, unclear voicing and sudden changes in tone.
Conclusion: Overall, CLF-PROVE proved to be a feasible tool for conducting surveys in Africa. The pilot testing of CLF-PROVE has identified adjustments required to refine the system and ensure it meets its objectives supporting wide scale medical surveys across the continent.

Keywords: Development, testing, Interactive Voice Response System, COVID-19 vaccination outcome monitoring, Uganda, Malawi.

1 Introduction

In March 2020, the World Health Organisation (WHO) declared a pandemic of COVID-19 [1]. This COVID-19 pandemic has affected the entire world, including Africa. As of July 2022, Africa recorded over 11 million cases with more than 250,000 fatalities due to COVID-19 [2]. To reduce the impact of the disease, vaccines were identified as the most effective strategy to combat the pandemic [3], with COVID-19 vaccine deployment in most African countries beginning in early 2021 [4].

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WHO recommends vaccine outcome monitoring and surveillance systems to help identify potential safety issues and inform the development of appropriate measures to mitigate risks and improve vaccine uptake [5]. Traditionally, paper-based surveys and phone calls have been used to collect information on vaccination outcomes [6] [7]. However, the use of such methods has been known to have limitations, including underreporting, incomplete information, and delays in data collection and analysis [6]. Furthermore, low and middle-income counties in Africa frequently have inadequate infrastructure and frameworks for vaccine outcome monitoring, especially in outbreak conditions.

IVR systems can potentially serve as a practical and cost-effective means of collecting health information to address this challenge. IVR systems are automated phone-based technologies that send recipients pre-recorded messages with menu options prompting them to provide feedback via the phone's keypad. These systems can also schedule calls at particular times and route all calls to the regular telephone communications networks. As the IVR systems are automated, they can allow real-time data collection and can reach a large and diverse population, including those with limited internet and mobile devices. As they use voice rather than text, they are suitable for those with low literacy levels and have been found to be acceptable in African populations [8].

Under the Infectious Diseases Institute, the Academy for Health Innovation built a locally adapted IVR system called Call for Life (CFL) to collect and transfer health information using the existing phone networks. CFL was initially developed to reach out to people living with HIV [9] and has since been adopted for use in TB, COVID-19 management and surveys. The IVR system was implemented for managing HIV amongst the young adults in Uganda and the participants reported improved medication adherence, strengthened clinician-patient relationships, and increased health knowledge from health tips [8]. The IVR system was also customised for COVID19 psychosocial support and the Ministry of Health adopted it for Uganda's national guidelines for management of COVID19 in 2021 [10]. The tool contains a web-based application that was built using OpenMRS and it manages participant registration, call scheduling, and report generation, among other system administrative roles. It also has a database which stores and retrieves patient data as well as an IVR server that routes the calls to the participants through Session Initiation Protocol (SIP) trunk, which is managed by telecom providers. SIP defines the messages sent from the IVR system to the users' phones while enabling and managing the voice calls.

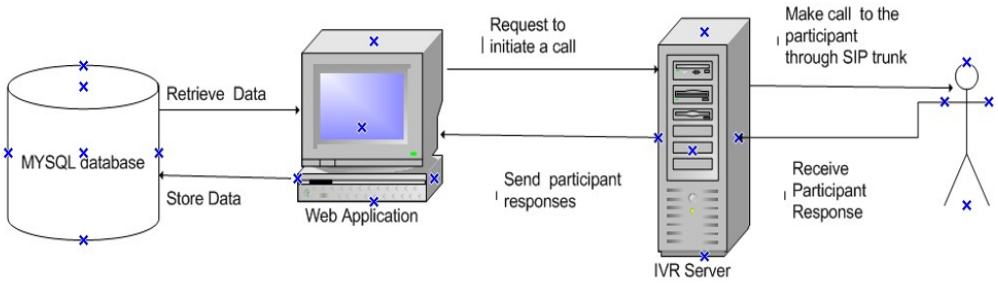

Figure 1: CFL-PROVE architecture

This paper describes the development and testing of CFL-PROVE; an adaptation of the CFL tool for PROVE. PROVE is an implementation science research program under the Africa Centre for Disease Control and Prevention (Africa CDC) Saving Lives and Livelihoods (SLL) initiative to support research on COVID-19 vaccination across Africa. We also present preliminary results from the testing of the CFL-PROVE, including the completeness and quality of the tests, and discuss the lessons learned during this pre-rollout phase.

1.1 Main Objective

To develop, test, and ascertain the feasibility of an IVR Survey system for vaccine outcome monitoring and use in multiple Africa countries.

Specific Objectives

- To understand the requirements for developing and deploying an IVR system for conducting vaccine outcomes across multiple African countries.
- To develop and test an IVR system for conducting vaccine outcome surveys in African countries.
- To ascertain the feasibility of using the IVR system for conducting medical surveys in multiple African countries.

2 Materials and methods

2.1 Requirements gathering

The Developers of CFL-PROVE from the Academy for Health Innovations hosted at the Infectious Diseases Institute held weekly collaborative meetings with the PROVE research team from April 13, 2022 to July 7, 2022 to discuss the requirements for the system. Data that needed to be captured during the survey were identified through these sessions. These data included consent information, demographic characteristics, the survey format and additional content that needed to be disseminated to the participants. The sessions also captured the languages required by participants across different countries where the tool was to be implemented together with any other country-specific considerations. A development roadmap and an initial requirement specifications document were created to guide and track the process.

At the end of the requirements-gathering phase, the team agreed to develop CFL-PROVE with the following specifications for each instance, a server setup of CFL customised for a specified use case. These included:

- A registration form that allows the data collector to record the participant's initials, gender, study number, address and phone number.
- A search functionality that enables users to find the participant they have enrolled by their initials, phone or ID.
- A feature to initiate calls to users such that they can listen to the consent (registration) call.
- A scheduling feature that enables data collectors to set up an automated follow-up call to be sent to the participant on the 28th day after registration.
- A language selection feature to allow participants to choose either an official language (English/ French) or a native language.
- Generation of a report that shows the participants' responses during the follow-up call.
- Translate the system user interface from English to French for usage in francophone countries.

2.2 System development

After completing the requirements gathering detailing the creation of different instances for each country, customisation work began between July 4, 2022 and December 7, 2022. The following activities were conducted during systems development:

- The user interface was customised to include the required fields for entering participant data.
- An automated report template was designed to enable users to generate reports that show participants' responses.
- Call Flows – the path that the recipient of a call takes during a call to guide their response journey, were designed and developed. Part of this process included the following:
    - Transcription in English
    - Translation into other languages (Luganda for Uganda users and Chichewa for Malawi)

    - Voicing and review of audio files
    - Uploading and redesigning the IVR call flows to match the audio files
- Setting up international calls in collaboration with telecom service providers in Uganda using SIP.

The system development procedure was iterative. Consequently, whenever the developers added a new feature to the system, the PROVE program staff were given access to the CFL platform to test its functionality. This enabled them to interact with the design and ascertain that features were functioning as specified. When testers identified any issues with the system, they reported it to the developers through email, verbal communication, and WhatsApp messaging. The developers would then fix the problems and repeat the cycle.

The final system called the registered participants twice. When the participant received the first call, it played the language selection message, greeting, consent information and an exit message. While on receiving the second call, it played the greeting message, it then asked the participant about their COVID-19 experience followed by an exit message.

2.3 Testing of CFL– PROVE in Uganda and Malawi

To ensure that the system is functional, user-friendly and of good quality, the developers subjected CLF-PROVE to testing in Uganda and Malawi. During testing a new instance, the test participants, including PROVE program staff, reviewed the user interface, call flows and reports to ensure all items in the requirements had been correctly implemented. Any faults or omissions were referred to the development team for fixing.

In Uganda, the developers demonstrated CFL to 32 PROVE program staff, with four staff registered to receive calls and provide verbal feedback on the user interface, report template and the order of the snippets in the Call flow. The staff were given access to the system to enrol themselves as participants between 21st July 2022 and 11th January 2023 and receive the registration and follow-up calls in English and Luganda using the CFL-PROVE system. The testers provided feedback on the system's usability, the correctness of the audio messages, the order in which the files are playing and audio quality through email and phone calls.

In Malawi, the developers enrolled three PROVE Malawi project staff on the tool, and they each received a consent call and multiple follow-up calls such that they could review all the possible call sequences and user inputs. A demonstration of the CFL system was performed for 27 PROVE program staff in Malawi, and they were given access to the system to enrol themselves and listen to the registration and follow-up calls. These staff tested the calls in English and Chichewa (a local language spoken in Malawi) between 30th November 2022 and 7th April 2023. They provided feedback about the correctness of the snippets in the call flow, the order of the snippets and the audio quality. The reviewers noted that the Chichewa audio files were of poor quality and they were referred to the service provider for a second attempt at voicing.

We determined completeness of the calls by calculating the percentage of calls that had all questions answered. Feedback on the quality of calls was obtained through interviews from a few selected testing participants.

3 Results

During the testing phase from July 2022 to April 2023, the IVR successfully sent 160 Ugandan and 140 international calls to Malawi.

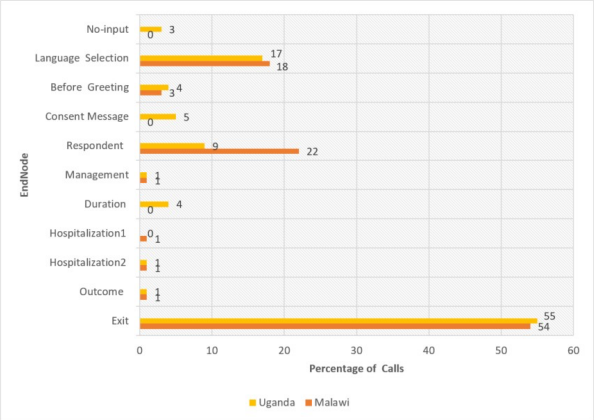

Figure 2: End Nodes of tested calls in Uganda and Malawi, July 2022-April 2023

The registration call had four messages including: 1.1. Language Selection; 1.2. Greeting; 1.3. Consent Message; 1.4. Exit. On the other hand the follow-up call had seven messages including: 2.1. Greeting; 2.2. Who is answering the phone? (Respondent); 2.3. From where was the participant managed (Home or hospital)? (Management); 2.4. The number of days the participant spent in hospital (Duration); 2.5. Was the participant oxygenated? (Hospitalization1); 2.6. Was the participant taken to ICU? (Hopitalization2); 2.7. Participant status in terms of recovery (Outcome). Figure 2 shows the call percentage versus "endNodes" (The message that had been played before the call was terminated). In Uganda, 55% (88/160) of the calls were completed (exit), with 17% (27/160) ending at endnode 1.1- language selection and 3% (5/160) terminated with no input. In Malawi, most calls that is, 54% (76/140), were completed (exit), followed by those that stopped at endnode 2.2 - respondent question at 22% (31/140), and language selection at 18% (25/140).

We received feedback on the call quality; 89.8% of reviewers reported good quality. However, 10.2% reported network interruptions in both countries. For those who gave positive feedback, the following is an example of their responses: "*Wow, the quality is top-notch, but the ending is so abrupt, as if we are in a hurry to end the call.*" Testing participant from the Uganda PROVE site. For those who reported challenges, the following are some of their comments: "*The voice keeps changing from soft to deep, then hoarse."* Testing participant from the Malawi PROVE site. "*I got around six questions; the audio quality is okay, but due to network challenges, I missed some of the words in one of the questions. I am happy to do another interview such that I choose different responses to the questions*" Testing participant from Malawi PROVE site.

4 Discussion

Developing and testing CFL-PROVE for monitoring vaccination outcomes for the PROVE program was an iterative process that encouraged stakeholder engagement. CFL was initially designed to support adherence and health messaging amongst PLHIV and TB patients. It was later adapted for COVID surveillance and psychosocial support. Through this project we have shown feasibility for CFL-PROVE, an African based solution which can enable large scale population surveys in multiple countries.

During the development of the CFL-PROVE, we learned a few lessons and achieved some milestones. First, we developed expertise in configuring the IVR system to undertake international calls. CFL-PROVE was designed to use SIP - a signalling protocol for initiating, maintaining, and terminating communication sessions, including voice, video and messaging applications. Initially, the team engaged various in-country telecom service providers in countries where the IVR system was to be implemented to provide SIP trunks. Having an in-country SIP trunk is typically cheaper than making calls through the already existing channels that the Ugandan telecom service providers support. However, these attempts were unsuccessful. For

example, the telecom company contacted in Malawi did not have the necessary infrastructure. Consequently, the SIP trunks hosted in Uganda were re-configured to permit the routing of international calls. While investigating the issue hindering calls from being routed to Malawi numbers, the developers understood the configurations that must be made on the IVR system to permit international calls from the telecom's SIP provider's channels.

In addition, we also developed expertise in translation of the User Interface from English to French. Whilst we have always used different languages for the calls, the CFL user interface (UI) for the systems administrators and operators was previously in English. Translation of this into other languages presented a unique challenge, especially in the context of the OpenMRS platform on which it is based. Multiple layers of code in all system parts (presentation, business and database layers) had to be re-designed, upgraded, and in some cases, hard-coded (intending to refactor later) to provide the correctly translated words on the right pages in the UI. This work has enabled the team to garner technical skills in OpenMRS UI translation. One of the challenges we found was the high cost of calling from Uganda through the regular Public Switched Telephone Network (PSTN), which incurs international call rate surcharges per call. To ensure sustainability, efforts are being made to source for SIP services from local telecom companies, which will reduce the cost of calls. Among the challenges experienced was the absence of active COVID-19 cases in the countries where the CLF-PROVE system was to be implemented in a prospective study. The IVR has been re-purposed to collect retrospective-type data within the scope of the study, and development work is underway to modify the tool. Customizability of CFL reduces production cost due to shorter development time required for adapting the system to a different use case as compared to re-inventing the wheel; hence, it is a sustainable tool.

Acknowledgements

We want to thank the program sponsor, Africa Centres for Disease Control and Prevention (Africa CDC), and the Infectious Diseases Institute (IDI) for championing the program development and implementation of the IVR system. We are also grateful to MasterCard Foundation through Saving Lives and Livelihoods (SLL) program for funding the work of developing and implementing the IVR across African countries. We also thank the internal developers at IDI who have worked tirelessly to customise the system to the required use case.

Statement on conflicts of interest

All the authors declare no conflicts of interest

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Journal of Health Informatics in Africa

Integrated data analytics systems to improve quality data outcomes: Case scenario from the Malawi Analytics Platform (MAP)

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1 Background and Purpose

Various implementing partners and stakeholders within the health care system use different and isolated data visualization software to communicate different health outcomes. The challenges attributed to this include reduced data use as stakeholders have to navigate through different systems to access visualizations for informed decision making and policy framing. We describe the creation of an innovative design of centralized access to diverse analytics and data visualizations known as the Malawi Analytics Platform (MAP).

2 Methods

MAP is a web-based system that hosts data sets, dashboards, and analytical workspaces from multiple sources including the Elizabeth Glaser Pediatric AIDS Foundation (EGPAF)-supported health information systems, among them the Central Data Repository. It provides streamlined data access for government, U.S. Centers for Disease Control and Prevention (CDC), and other stakeholders. MAP was developed and implemented by EGPAF with support from CDC Malawi and was completed and launched in August 2021. It integrates reports developed using various visualization software, like Microsoft Power BI, Tableau, Leaflet, Dash, and Metabase in one system. Reports are automatically added to the system from EGPAF's Microsoft PowerBI workspaces or embedded from the other Business Intelligence systems using URL links (Figure 1). Currently, the platform includes health analytics visuals from the Digital Health Division, Department of HIV/AIDS, and Laboratory Diagnostics within the Ministry of Health (MoH), Global Health Informatics Institute (GHII) and EGPAF-supported digital health systems.

The platform is compatible with mobile systems and can be remotely accessed. The flexible and scalable design accommodates the diversity of stakeholders who wish to manage and track data usage. Interested parties from these stakeholder groups can register on the platform but have to be authenticated by the custodian of the data before their account is activated for access. MAP includes a feature for obtaining feedback from these users on queries, comments, and/or suggestions to be made on the analytics visuals presented on the platform, based on their expert knowledge in the field, thereby promoting data quality. Succinctly, MAP represents a single centralized platform for users to access health data analytics while eliminating redundant systems administration and management of access permissions; and provides viewership trends to improve impactful analytics.

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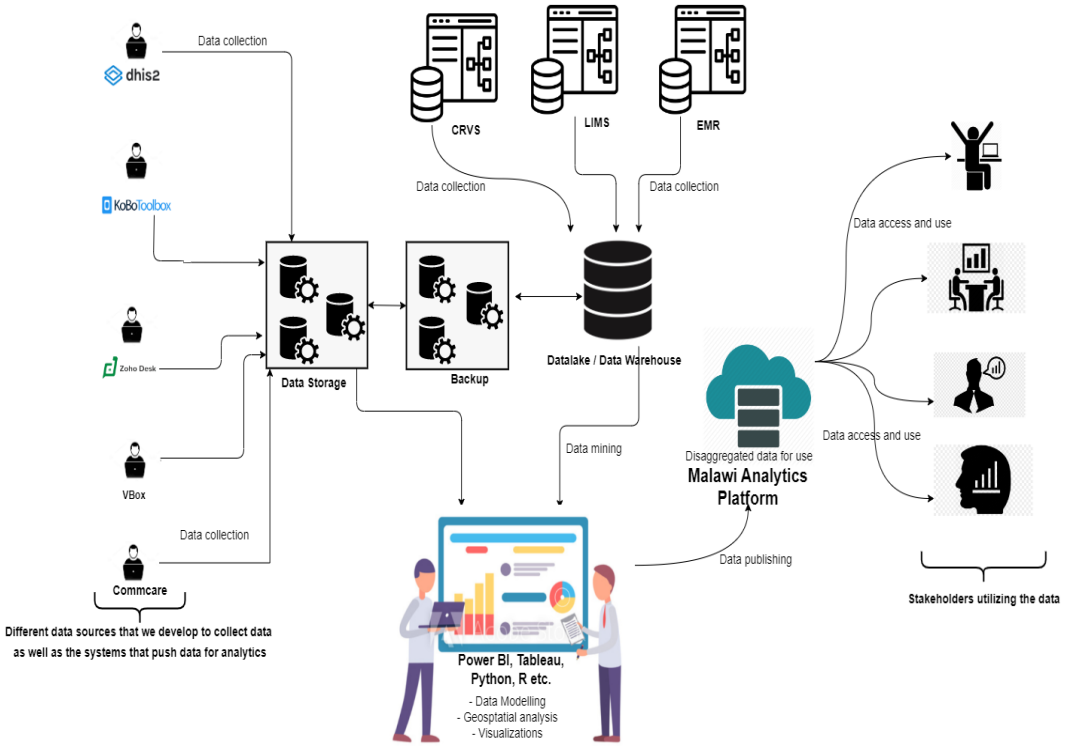

Figure 1: MAP Architecture

3 Results

MAP houses over 200 reports with over 500 users from 29 stakeholder groups. The most viewed reports are the EMRS HIV Quarterly Report, the Lab Information Management Systems Dashboard, and the TX Analysis (Continuity and Interruption of TX) Dashboard. The EMRS HIV Quarterly Report is of particular interest as it gives an overview of current HIV and AIDS trends from the 769 facilities supported by PEPFAR across Malawi. All these reports are being published and shared to all corresponding stakeholders including 220 health facilities which are accessing the service for free, leveraging on policy-based network traffic forwarding rules from MoH WAN to the internet and vice versa. Stakeholder groups with most views on MAP include CDC, MoH, EGPAF, and other partners. Currently, EGPAF staff contribute 73 percent (9,273/12,751) of the report views. Over time, report viewership in MAP has increased sequentially since its introduction in August 2021 from 145 to 12,751 as of May 2023. MAP also hosted COVID-19 Telephonic Syndromic Surveillance Dashboard that gained more views on MAP during the peak of COVID-19 in Malawi. This dashboard provided real time data from a telephone-based survey and informed MoH to monitor and respond to COVID-19.

4 Lessons learned

MAP has eased access for stakeholders in health to access different analytical products to support program management, disease control, and patient care in one platform. Stakeholders now have access to integrated data output reports that they can apply to improve the quality of services and respond to programmatic challenges. Furthermore, the platform has the potential to be used and promote data use and quality outside the health space.

5 Conclusions

MAP is a comprehensive, secure, and easy-to-access platform that promotes data-driven decisions in public health. Diverse stakeholders and departments within MoH have access to integrated data products including intuitive and dynamic visualizations that guide program planning and disease response. Plans are underway to scale the platform and include visualizations from more stakeholders to subsequently have a one-stop system for all health-related analytics. More health facilities will also have access to MAP for decentralized data use and improve quality of care at site level. A user-friendly system that is already in use, MAP will require minimal user training to expand use of the visualizations, reports and data marts. EGPAF in collaboration with MoH, plans to continue refining the system to accommodate the diversified requirements across different stakeholders as well as build capacity for MoH to support and sustain the platform.

Journal of Health Informatics in Africa

How not to kill your patient: The role of implementation validation frameworks for sustainable digital health information systems

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The implementation of digital health systems still poses many challenges. Too many projects result in systems characterised by low user acceptance and limited operational use. Common barriers to system acceptance include a lack of ownership, too narrow focus on technology, and lack of confidence in the resulting data. In many cases the long-term sustainability of the digital health system and the expected return on investment is never fully realised.

This presentation will describe the system validation approach that incorporates the key concepts of infrastructure qualification, operational qualification, and performance qualification (IQ, OQ and PQ), providing insight into the benefits of this approach. Whilst formal system validation is a common practice in manufacturing processes and the integration of medical devices, it is not typically used in software implementations.

The presentation will describe experiences in adapting the ISBT Guidelines for Validation of Automated Systems in Blood Establishments [1], creating a validation framework that encompasses technology, people and processes. This provides formal assurance that the system performs as expected and produces consistent results, and is therefore a critical element in ensuring acceptance, uptake and reliability. Operationalizing the validation process forms is an integral part of change management, providing an opportunity to build a sense of real ownership and local capacity, and reducing reliance on vendors for support. Providing documented evidence that critical data is correct minimises risks to patient safety and provides users with greater confidence in the data. We will also discuss how this approach aligns with Digital Square's criteria for shelf-readiness of software global goods.

Keywords: Implementation, sustainable, digital health systems.

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Journal of Health Informatics in Africa

Exploring Opportunities and Challenges to Data Production of a FAIR Digital Health System: The VODAN Case Study

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1 Introduction:

FAIR refers to a principle that seeks to make data Findable, Accessible, Interoperable, and Reusable [1]. It aims to make scientific data more useful and meaningful for its curators and users. However, despite the increasing discussion about this, there are a few implementations of this principle to date, across the world. It is even less so, with health data [2, 3]. However, over the last few years, the Virus Data Outbreak Network (VODAN) have attempt to design and deploy a FAIR compliant digital health innovation across 75 health facilities eight (8) countries in Africa [4] including Uganda, Nigeria, Ethiopia, Kenya, Tanzania, Tunisia and Somalia. Working with Country Coordinators, trained data stewards, health facility administrators and data clerks of the project, the aim was to create a FAIR Data Point (FDP) with more than three (3) algorithmic pathways for the reuse of produced data [5]. However, data production did not go without challenges but also presents opportunities for future implementations. Using VODAN as a Case study, we aim to investigate the implementation experience of users and data. A case study research is used in order to fully comprehend the phenomenon that is being studied. The case study research is a thorough examination of one unit with the goal of generalizing to a broader group of units [6]. To do this, we conducted interviews with select twenty (20) stakeholders from five (5) of the eight (8) countries, to understand the facilitators and impediments to data production within the VODAN network. We have made preliminary exploration of the data as outlined below

2 Methods

For data collection, we employed qualitative methodologies. Initially, we conducted detailed online interviews through Zoom with Twenty (20) Country Coordinators and Data Stewards from Nigeria, Kenya, Ethiopia, Somalia, and Uganda, with each session lasting between 45 to 60 minutes. Additionally, we utilized Critical Incident Theory during the interviews to encourage further discussion and obtain additional information regarding the technical issues that were reported. Purposeful sampling was used to select health facilities, to enable us obtain a responsive data.

For data analysis: we will use Nvivo 12 to code, analyse and clean up the data that was collected basing on themes that were derived from research questions. During the analysis of the responses, the researchers will articulate what the responses meant and record the emerging themes. Similar themes and subthemes will be categorized and grouped together. Video recordings will be replayed where necessary to ensure completion. Before every theme is analysed, the researchers must read the responses of each informant that participated in the study to gain in-depth understanding. To ensure data accuracy, direct quotations from the informants are proposed to be used and can be anonymously used to describe data.

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3 Results

Our preliminary data exploration indicate that there are existing opportunities that was leverage upon including existing technology orientation of users and organisational policies. However, capacity building have also facilitated the availability of data within the pipeline. In contrast, a lack of intrinsic motivation, lack of sufficient electricity and internet connection, and a lack of a mechanism to evaluate data quality timeliness appear to be common barriers that affect the data production in the studied VODAN digital health system. In the future, we hope to determine and report the factors that contribute to the identified social and technological facilitators and barriers to the data production.

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Journal of Health Informatics in Africa

Measurement errors in big data: an approach with high-dimensional microarray data

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Big data (in the sense of high-dimensional data) are sometimes subject to measurement errors. Gene expression microarrays is an example of high-dimensional data subject to various sources of systematic and random error, which are noisy versions of the true gene expressions in the patients. We compare regularized selection methods that do not require additive information about the measurement error structure or the covariance matrix of the measurement error in high-dimensional generalized linear models and focus on variable selection with Gaussian and binomial response. Our approach is a result of a combined procedure consisting of first selecting highly correlated variables and then applying a selection method to the selected variables. This technique helps handle the situation where the number of predictors can be above tens of thousands greater than the number of observations. Our method reduces considerably the number of false positive and the estimation error in microarray data.

Keywords: Generalized linear model, high-dimensional data, measurement error, big data, gene expression.

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Journal of Health Informatics in Africa

Digital Approaches to Supportive Supervision: A Pathway to Improving Health Services and Data Use in Ghana

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Background and Purpose: Supportive supervision is the process of mentoring staff to improve their own work performance continuously [1]. Supportive supervision has been implemented widely across a variety of health areas, but often lacks structure, continuity from prior visits, and fails to be data-driven. As digital tools in the hands of frontline health workers have proliferated and systems have been developed to share data with supervisors and district managers, an opportunity to develop digital supportive supervision tools has emerged.
Methods: To provide a standard approach for these digital tools, the implementing partner has developed a guidance document titled "Digital Approaches to Supportive Supervision: Guidance Framework", to standardize the approach and language for digital health actors to discuss digital interventions that can strengthen supportive supervision systems and make them more data-driven.
Results: The CHISU framework focuses on four user personas- the supervisor, the provider (supervisee), the program manager who oversees the supervisor, and the client receiving care. The framework maps 13 digital components to the 6 phases of the supportive supervision cycle to enable more data-driven supportive supervision. The framework was implemented in Ghana and Malawi to develop recommendations for further strengthening the digital tools in their supportive supervision ecosystems
Conclusions: The framework can be used to support countries to define the key components needed for digital tools for supportive supervision. When implementing the framework, it is important to work within the governing structures and guidance documents for supportive supervision to align the program goals with digital components prioritized.

Keywords: supportive supervision, framework, integration, digital

1 Introduction

Supportive supervision (SS) is the process of mentoring staff to improve their own work performance continuously [1]. It is undertaken to ensure health workers have the support and resources they need to do their work, to measure and improve quality of care, and to identify gaps to be able to solve problems as they arise [2].

1.1 Challenges of supportive supervision

Supportive supervision has been implemented widely across a variety of health areas, but often lacks structure, continuity from prior visits, and fails to be data-driven. Additionally, inadequate supervisory skills and lack of transport for supervisors have been noted as barriers to effective supportive supervision [2]. Communication and feedback are important aspects of supportive supervision that often do not receive enough attention and resources in supportive supervision programs [3].

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1.2 Digital approaches to supervision

As digital tools in the hands of frontline health workers have proliferated and systems have been developed to share data with supervisors and district managers, an opportunity to develop digital supportive supervision tools has emerged.

SS is typically based on formal checklists reviewing facilities or teams and may include assessing equipment, infrastructure, quality of care, staffing, and management issues as well as service delivery. In order to facilitate continuity between supervision visits, observations and feedback, along with action plans to address any challenges or areas for improvement should be documented. Digital tools can facilitate this longitudinal record-keeping of supervision visits and make these records accessible to the supervisor to review prior to a supervision visit to provide historical performance context. Some supportive supervision tools are bringing together data from various sources to use as a tool in reviewing service delivery or data quality to enable supportive supervision to be more data-driven and set priorities for who or what facility needs supervision.

2 Materials and methods

2.1 Framework development

To provide a standard approach for these tools, the implementing partner has developed a guidance document titled “Digital Approaches to Supportive Supervision: Guidance Framework”, to standardize the approach and language for digital health actors to discuss the wide array of digital interventions that can strengthen supportive supervision systems and make them more data-driven. This framework is designed to support country decision-makers in identifying and selecting which digital interventions are appropriate in their context.

To develop the framework, a landscape analysis of digital tools for supportive supervision was conducted, followed by numerous consultations with stakeholders who have developed or implemented digital approaches to supportive supervision. Using the landscape analysis and consultations with stakeholders, we identified key user personas who interact with supportive supervision, a generic supportive supervision cycle, and digital components that are used by the user personas at different phases of the supportive supervision cycle.

2.2 Framework implementation in Ghana

The framework development team partnered with the Ghana Health Service (GHS) to implement the framework. A landscape review was conducted to understand the organization of supportive supervision in the country, the goals of supportive supervision, and any digital tools that were in use. This information was then synthesized and presented at a workshop with key stakeholders. Stakeholders then discussed which digital components identified by the framework that they would prioritize for strengthening their supportive supervision systems.

3 Results

3.1 Digital Approaches to Supportive Supervision Guidance Framework Content

The CHISU framework focuses on four user personas- the supervisor, the provider (supervisee), the program manager who oversees the supervisor, and the client receiving care. Breaking up the phases of the supportive supervision system into: 1) preparation, planning, budgeting; 2) direct observation of care, inspection, interviews, 3) problem solving, feedback, coaching, joint consensus, 4) training, 5) reporting, 6) follow-up, the framework identifies digital components that can be used to strengthen each of these phases individually or holistically. 13 digital components were identified that can be used to strengthen each of these phases individually or holistically to enable more data-driven supportive supervision. These

components are: automated prioritization, pre-scheduled tasks/reminders, aggregate performance data, dynamic dashboards from real-time data, comparative data across health workers, triangulation of data across multiple systems, longitudinal progress over time, digitized visit checklists, digital requests for support, tracking of action items, multimedia training materials, mobile self assessments, audio/visual calls.

3.2 Initial outcomes of framework implementation in Ghana

3.3.1 Supportive Supervision context in Ghana

Ghana is currently implementing two kinds of supportive supervision, the On-site Technical Supportive Supervision (OTSS) for malaria case management activities with malaria clinical and microscopists and integrated supportive supervision (ISS) for all other service areas (on-site). Both kinds of SS are fully digitised on the Health Network Quality Improvement System (HNQIS) tool from 2020, which runs on mobile devices (Smartphones and tablets). The Region and the District Health Directorates plan together to execute quarterly digital supportive supervision for all health facilities, deploying a district level supervisory team that comprises a multidisciplinary peronelle that skill matches the technical area to supervise. After the quarterly visit, the district teams then identify their service gaps after data analysis and prioritize the gaps they want to address in a process of quality improvement. Action or response plans are developed together digitally on HNQIS with the facility staff on the areas that need improvement before the supervisory team leaves the facility. The national ISS tool boasts 6 digitized processes 1) Prepare and Plan, 2) Assess facility/conduct visit, 3) Guidance and Feedback, 4) Documenting and reporting, 5) Support and Follow up, and 6) Review. ISS faces challenges with integrating its data on HNQIS with DHIS2, lack of follow-up on feedback and assessments, poor coordination with implementing partners who invest in digital tools that are not interoperable with ISS server, lack of ISS indicators at the national level and server infrastructure.

3.3.2 Recommendations for Ghana based on implementation of the framework

Existing platform functionality optimisation for improved triangulation of data and interoperability of supervision data:
Triangulation is a key digital component within the framework, which aims to support supervision design to share key indicator data that is gathered from supervision visits, that could be shared cross-sectorally to support other programme areas such as Maternal Health and supply chain for example. At present, Ghana's supportive supervision data is hosted on a DHIS2 instance which is not interoperable with other programme health information systems. It means HNQIS also cannot pull data from other programmes to provide a more holistic database, that can also pre-populate some indicators within quarterly supervision visits which could reduce duplication of data collection at health facilities.

Improved longitudinal performance tracking of supervisors/supervisees: Despite having a digital action plan module for a supervisor to conduct post assessment, GHS reported this data is being very underutilised in the way that is stored. There are no 'on - app' indicators to measure action plan implementation or baselines to demonstrate improvements in performance visit to visit.

Integrating E-Learning platforms into SS tool: One of the final recommendations was to integrate the government's e-learning platform into HNQIS for stronger update and implementation of remote refresher trainings to support knowledge retention and greater cost-effectiveness. Currently, it is a separate web UI that isn't available on mobile devices which also impacts ease of access and use.

4 Discussion

Through these initial implementations of the framework in Ghana, we have demonstrated that the framework can be used for use cases it was designed for: 1) defining and providing a common language to describe what should be included in a supportive supervision system, 2) assess an existing supportive supervision cycle and identify what digital components could be included in a supportive supervision system, 3) assess an existing ecosystem of digital supportive supervision tools to determine adaptations to improve the system, and 4) develop a vision and roadmap for what digitalization of supportive supervision is desired for specific supportive supervision program. Finally, when utilizing this framework, it is important to bear in mind that digital approaches to supportive supervision should be highly adapted to the supportive supervision context. Supportive supervision programs have many varying levels of maturity, goals, structures, and stakeholders. These differences, in addition to variations in availability of human resources and physical infrastructure to maintain digital systems, mean that the digital components selected and implemented for supportive supervision will vary greatly from one context to another.

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Journal of Health Informatics in Africa

Implementation of Central Data Repository Lessons from Malawi

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1 Introduction

Malawi has been a leader in regional HIV/AIDS epidemic response for nearly two decades. Since the early 2000s, the Malawi Department of HIV/AIDS (DHA), with support from the U.S. President's Emergency Plan for AIDS Relief (PEPFAR), has collected quarterly, aggregate site-level data on important HIV/AIDS program indicators to guide program response, inform national progress to targets, and facilitate appropriate supply and demand systems. Concurrently, the U.S. Centers for Disease Control and Prevention (CDC)/PEPFAR has supported DHA and the Ministry of Health in building systems—including an Electronic Medical Record System (EMRS), a National Laboratory Information Management System (NLIMS) and Civil Registration and Vital Statistics System to facilitate both improved patient care and strengthened M&E. These systems sync data to the Central data repository (CDR). The goal of the CDR is to enable integration and cross-sectional data analysis, for multiple population categories and to store the data in a secure and robust repository. This paper describes implementation of the CDR and lessons learned from Malawi.

2 Method

To achieve the goal of data integration from multiple electronic systems, it was imperative to establish a system based on shared language (syntactic interoperability) and shared understanding (semantic interoperability) from the outset. A shared language reduces confusion from issues such as multiple terms with the same meaning or multiple spellings of the same term. Additionally, a shared understanding provides confidence that the terms being used mean the same thing to everyone. This created an enabling environment for users to work together and interoperate as they share and interpret data across multiple systems. Data repositories that incorporate shared languages and understanding into their programming are dubbed 'intelligent'. Standards were established for each of the different pieces of data to be collected and synced into the central data repository. A data dictionary has also been created to define the variable names, labels, tables, relationships, and allowable values for variables. Data dictionaries are an essential component in making the database contents understandable by both users and intelligent processes.

A network infrastructure was established covering 232 point of care sites to allow real time data capturing and transmission on to the CDR. The remaining 518 eMastercard sites capture data retrospectively and transmit data to the CDR quarterly. The central data repository was set up on the CISCO hyperconverged infrastructure which provides a centralized environment to manage data collection, integration, storage, and analytics. The hyperconverged infrastructure combines computation, virtualization, storage, and networking in a single cluster. To allow verifications of data sets in the CDR vs site level databases, a raw data store (RDS) which is a replica of the site level data base was implemented. The reconciliation process was configured to compare data sets in the CDR vs site level servers. This process offers a first layer of CDR data quality assurance. Data is transformed through an extract transform and load (ETL) process to a usable format to allow user analyses to support decision making for programming and planning. The ETL process was facilitated by the PENTAHO data integration tool which

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is one of the most widely used ETL solutions and has higher ratings in the health informatics landscape. It has a long history, solidity, robustness that makes it a highly recommended tool.

3 Results

We successfully established a CDR to collect data from multiple electronic systems that are implemented in the health facilities. The repository runs on MySQL and postgres database engines. The pieces of data that are stored in the CDR include observations, encounters, and metadata among others. At the Intermediate Data Store (IDS) level we run the probabilistic de-duplication algorithm to help with picking up potential duplicates to ensure data quality. The algorithm uses a concatenated string comprising of first name, middle name, surname, date of birth, home of origin, and district of origin. It parses this composite key through the database and uses the bantu soundex to pick up potential duplicate records at 85% matching score and higher. PowerBI dashboards with drill down functionality have been configured and published on the Malawi analytics platform to promote data availability and use. Users submit their data requests for human subject research approval to the National Health Sciences Research Committee (NHSRC). The Central Monitoring and Evaluation Division (CMED) grants data management approvals. And data security clearance is approved by the Digital Health Division (DHD).

4 Lessons learned

Development of a central data repository is a critical and time-consuming activity. It requires a clear definition and documentation of the overall aims and objectives. It also requires adequate staffing including segregation of duties. Stakeholders keep changing requirements, therefore there is a need to have a solid governance framework to manage change. Users tend to think that all data quality issues emerge from the central data repository; however, all CDR data is inherited from source systems including data quality issues hence the garbage in garbage out concept applies. Metadata management is equally important in developing and operating the CDR. Lack of centralized metadata management leads to incorrect reporting especially when metadata becomes historic. Power and network outages derail development work as well as data processes. It is imperative to have a robust power and network infrastructure for the CDR.

5 Conclusion

The central data repository has simplified management of data collected from all the 750 facilities running various electronic systems. The electronic records system, lab information system and vital statistics systems can now integrate their data into the CDR. Furthermore, implementation of the CDR has enhanced data availability and access to a wide range of users. Senior managers at national and subnational levels can run different analytics to monitor health outcomes. The central data repository has also enabled implementation of case-based surveillance to allow longitudinal analysis based on client level data.

Journal of Health Informatics in Africa

Technology Intervention Framework: A practice-based approach for generating evidence for digital health interventions

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1 Introduction

Digitally-enabled solutions and health informatics are playing a key role in shaping the way health services are managed, delivered, and accessed across communities in sub-Saharan Africa. Between 2019 and 2021, the digital health space in Africa has seen a significant increase in investments from $29 million USD to $123 million USD [1]. With the proliferation of digital health interventions, there is a need to understand the impact of these solutions on improving health outcomes to better inform digital health strategies, coordinate investments across stakeholders, and effectively allocate limited resources.

Evidence-based research like randomized controlled trials (RCTs) are considered the gold standard for evaluating the effectiveness of interventions. There are several challenges, however, with conducting RCTs for assessing digital health interventions – from long follow-up times to resource heavy study designs (i.e. labour). Furthermore, the controlled environments required for RCTs do not reflect the realities found in everyday practice. Some of these conditions are exacerbated in low resource settings, making it difficult to fully realize the results from these studies.

Practice-based evidence offers a practical method for generating evidence on the effectiveness of interventions without the rigid and controlled environments necessary in RCTs. The benefit of practice-based research to understand impact is the ability to examine the effectiveness of interventions in the same settings as everyday practice. While RCTs typically ask the question of whether an intervention causes an effect, practice-based research addresses the social and behavioural components impacting the success of interventions. An example of a practice-based research question may be "For whom does the digital health intervention work best?".

The Data Use Community (DUC), with support from the United States President's Emergency Plan for AIDS Relief (PEPFAR), is a global community of practitioners consisting of government officials, implementers, technologists, and donors working to advance the use of data and technology to improve health outcomes. Adopting a practice-based, community approach, the DUC brings together community members monthly to share best practices, in-country perspectives, and lessons learned related to developing and deploying digital health interventions in Africa – with the goal of collecting and documenting the impact of these solutions.

The Technology Intervention Framework (TIF) was developed in response to the need for a shared language when describing the implementation considerations and functionalities of digital health solutions for HIV treatment continuity. After several presentations of various digital health interventions for the same problem, it became clear that a systematic way of organizing and sharing information was necessary to facilitate strategic dialogue among community members. The aim of this experience paper is to describe the DUC's approach to developing the TIF, and to provide an overview of the different layers of the framework and how it can be used to collate and synthesize practice-based evidence.

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2 Methods

A qualitative approach was used to develop the TIF that consisted of systematic literature reviews, contextual analysis, observations, and knowledge sharing. Monthly community events showcasing digital health solutions were organized to gather practice-based evidence from the field. A canvas, adapted from the Business Model Canvas, consisting of various attributes was developed as a visual representation for organizing and communicating technical functionalities, governance, and implementation considerations for an intervention [2]. An iterative and co-creation process including community working sessions facilitated further refinement of the TIF.

3 Results

The resulting TIF consists of three layers: 1) Touchpoints, 2) Intervention Categories, and 3) Technology Intervention Descriptions. The first layer, Touchpoints, represent the exchange of information or services between patients and the health system (Patient Touchpoint), as well as between other members such as administrators engaging with the health system (System Touchpoint). These touchpoints serve as the foundation for examining how digital health interventions support the exchange of data and services between the different parties. The goal of this layer is to determine at which point of the visit cycle – outside the visit, during the visit, missed appointment – does the digital health solution support the different touchpoints. The second layer, Intervention Categories, identifies the types of patient and systems-level interventions for the different touchpoints within the visit cycle based on best practices for care pathways. The final layer, Technology Intervention Descriptions, offers a visual representation or "canvas" of various attributes to organize and describe the digital health interventions. The canvas attributes include: Data Elements, Evidence, Technology Requirements/Interoperability, Calculations/Algorithms, Factors to Scale, Implementation Considerations, and Governance Considerations.

4 Conclusion

Since 2021, the DUC has been sharing best practices and lessons learned developing and deploying digital health interventions for HIV treatment continuity. It has gathered and synthesized practice-based evidence and experiences for 24 digital health interventions primarily in Africa. While the TIF was initially developed to assess the impact of digital health solutions for HIV, it has broader applications across health domains. It offers decision-makers a resource for understanding the types of digital health interventions that have been implemented in everyday practice by assessing the intersection of technology and health informatics. By standardizing the way different functionalities are communicated, it bridges the way digital health approaches are analysed across various stakeholders.

Keywords: practice-based evidence, digital health, framework.

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Viability of telephonic verbal autopsies in South Africa (2021)

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Background and Purpose: Accurate cause-specific mortality statistics are crucial for informing health priorities and policies, but many countries struggle with limited Civil Registration and Vital Statistics (CRVS) systems. Verbal autopsy (VA) methods have emerged as a way to estimate causes of death in populations lacking robust CRVS systems. However, traditional VA approaches requiring in-person interviews can be labor-intensive and time-consuming. This pilot study aimed to assess the feasibility and acceptability of telephonic verbal autopsies (teleVAs) as an alternative to face-to-face interviews for determining the cause of death in out-of-facility decedents in South Africa.

Methods: The study employed telephonic interviews, surveys, call-logs and in-depth interviews to assess the feasibility and acceptability of teleVAs. The study was conducted in the Cape Town metro, with two additional sites in rural KwaZulu-Natal and rural Mpumalanga, to assess the qualitative component of the study. A total of 1347 next-of-kin (NoK) were approached for interviews.

Results: The overall response rate was 17%, and 64% of successfully contacted NoK agreed to participate. Incomplete or incorrect contact details posed a major challenge in collecting NoK information. There was acceptability among interviewers and respondents, and minimal technical challenges. Interviewers required time and training to adapt to conducting VA over the phone, and respondents reported positive perceptions and comfort in participating in teleVAs.

Conclusions: TeleVAs could be an efficient alternative for conducting VAs, but challenges in identifying and recruiting NoK and training interviewers to handle phone interactions need to be addressed. Future work should explore the potential use of teleVAs in CRVS systems with potential stakeholders.

Keywords: Verbal autopsy, mortality information system, digital health

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Journal of Health Informatics in Africa

Customizing and Adopting the AU Health Information Exchange Guidelines and Standards Framework for the Federal Ministry of Health in Ethiopia

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Background and Purpose: Africa CDC and African Union have developed a Health Information Exchange Guidelines and Standards Framework (AU HIE Framework) to promote interoperability and data exchange within and between African Member States. Ethiopia's Ministry of Health previously developed policies and frameworks supporting interoperability and standardisation among health information systems in Ethiopia, including Ethiopian Electronic Health Record (EHR) standard guidelines and proposed HIE as a possible supporting architecture.
Methods: CDC Ethiopia initiated a project to customize and localize the AU HIE Framework for potential adoption in Ethiopia using a team under the CDC Technical Assistance Platform program including the University of Gondar and Jembi Health Systems. The team localized the AU HIE Framework and validated it with the Ministry of Health and other experts in Ethiopia. The final draft version was presented by the Ministry of Health pending final approval by Government of Ethiopia.
Results: The AU HIE Framework enabled the Ethiopia Guideline to be developed in a short time. The Ethiopia Guideline is consistent with the other health information system policies in Ethiopia and was endorsed by expert panels. The Ethiopia Guideline provides standards (e.g.,HL7 FHIR™) recommended by system developers for interoperable systems, and can be extended to support specific digital health goals such as interoperability between existing and new systems.
Conclusions: Customization and adoption of the AU HIE Framework had several benefits including shorter development time and consistency with the Pan-African Guideline. It will facilitate discussion and planning for technical interoperability within Ethiopia and other African member states.

Keywords: Health Information Exchange, Data Integration, Health Interoperability Standards, Health Information Systems Governance

1 Introduction

To combat disease outbreaks and pandemics, such as HIV and COVID-19, data sharing among health system levels is essential. The Africa CDC developed a Health Information Exchange Guideline and Standards Framework (AU HIE Framework), which the African Union subsequently adopted (1). The purpose of the Framework is to promote data and health information exchange between and among member states. The principles and content in the framework are applicable to cross-border data exchange, as well as within a particular country.

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Interoperability to support data exchange is a challenge in many low-resource countries. In addressing interoperability and data exchange internally within countries, one of the first steps needed by Ministries of Health is to develop a policy document to direct activities to address these challenges. These include the adoption of interoperability standards and health architectures promoting interoperability, data integration and health information exchange. To meet the needs for in-country use, the policy needs to be appropriate for the local context and be consistent with other health information system policies and guidelines. In Ethiopia, these are provided by several policies developed by the Ethiopia Ministry of Health (MOH), including the Information Revolution Strategic Plan (2018-2025) (2) and the Ministry of Health of Ethiopia eHealth Architecture, Version 1.5. July 2019 (3).

2 Materials and methods

Ethiopia MOH and CDC Ethiopia, and implementing partners of the Technical Assistance Platform (TAP) program (TAP), University of Gondar (UOG), Jembi Health Systems and Compelling Works led the effort to review the AU HIE Framework and adapt it as the Ethiopia Guideline to meet local needs. The content was aligned around other policies in Ethiopia, such as the Information Revolution Roadmap (2) and the Digital Health Architecture of Ethiopia (3). Experts from the UOG, Jembi and Compelling Works carefully reviewed and harmonized the draft Guideline with standards that have already been adopted or recommended for adoption in Ethiopia. Use cases were selected from among priority programs in Ethiopia to demonstrate application of the Guideline to real world scenarios: COVID-19, HIV Service and ANC Service Use Cases.

The draft Guideline was presented for review to several technical groups in Ethiopia and to the MOH during a workshop in June 2022: MOH Health Information Technology Team; MOH Policy, Plan, Monitoring and Evaluation Team; Ethiopian Public Health Institute Team; A University with digital health experience; Non-governmental digital health partners. The MOH and its partners made a number of suggestions during the workshop which were incorporated. The MOH also appointed its panel to lead health information exchange (HIE) under the Director of the Health Information Technology to review and make recommendations for incorporation in the final draft Guideline. The expert panel thoroughly reviewed the AU HIE Framework document and made recommendations that were incorporated in the final draft Guideline.

3 Results

Customization and local adoption of the AU HIE Framework enabled the Ethiopia Guideline to be developed in a short time. The Ethiopia Guideline is consistent with the other health information system policies in Ethiopia and was endorsed by technical groups and expert panels. The Ethiopia Guideline provides a catalogue of policies and standards (eg HL7 FHIR) recommended by system developers for interoperable systems, and can be extended to support specific digital health goals such as interoperability between existing and new systems.

Patterned after the format of the AU HIE Framework, the proposed Ethiopian Guideline comprises three main sections:

Section One: The Ethiopia HIE Policy for Digital Health Systems, including:
1. Governance framework,
2. Legal framework and
3. National Data Exchange Architecture, Reporting and Sharing

Section Two: Ethiopia HIE Standards for Digital Health Systems, including:
1. Data Exchange Standards, and
2. Privacy and Security Standards

Section Three: Three Key Use Cases representing priorities in Ethiopia, were further customized for Ethiopian context. Use cases:

1. COVID-19,
2. HIV Service, and
3. Antenatal Care (ANC) Service.

In general, the majority of comments raised by technical and expert reviewers dealt with Ethiopia-specific content and the processes for management and implementation of the guidance. It is important to understand the implementation of the framework and how it is implemented across the different jurisdictions in Ethiopia.

4 Discussion

The AU HIE Guidelines and Standards Framework was very useful for the development of a local guideline for Ethiopia. It effectively guided and increased the efficiency of the overall process for developing the Ethiopia Guideline. The structure and content of the AU HIE Framework provided a useful template for drafting the Ethiopia Guideline. Additional expected benefits include the promotion of standardisation, interoperability, data use and sharing in member states in Africa and the digitization of healthcare and effective data use in Africa. This will significantly strengthen data security as well as pandemic preparedness and response. In the future, it will also promote new guidelines such as the One Health Joint Plan of Action (4), particularly the exchange of data among different health, environmental and food security domains.

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Statement on conflicts of interest

None Declared.

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Implementation of a Data Warehouse for Surveillance and Immunization Program Improvement using DHIS2 in Ethiopia

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Introduction: The Expanded Program on Immunization (EPI) and surveillance data are critical in Ethiopia for program monitoring, logistics allocation, and improving child health outcomes. However, the data is dispersed across multiple sources and formats, unstructured, and not standardized. Therefore, the aim of this project was to create a data warehouse and visualization system based on DHIS2 to enhance access to and use of EPI and surveillance data for appropriate and prompt decision-making and actions.

Methods: DHIS2 was chosen as the ideal platform for integrating EPI data because of its extensive experience in reporting and data analytics at all health levels. The child health and data management teams identified prospective data sources for the EPI program and surveillance. Surveys, estimates of national immunization coverage, the Joint Reporting Form, Demographic Health Survey, and routine immunization data were used to compile the statistics. Appropriate indicators were based on the data triangulation national guidance developed by WHO, US CDC and UNICEF.

Results: The DHIS2-based data management system was developed and deployed at the Ministry of Health (MOH) data center [http://196.188.120.229:8080] and is currently being used by health managers, surveillance officers, and data managers at the MOH and RHBs for evidence-based decision-making to eliminate vaccine wastage and create accountability throughout the program. It is also serving to enhance the availability of data for prompt analysis and retrieval of key performance indicators. Prioritized indicators demonstrated the association between logistical distribution and vaccination utilization, indicating that there is a significant disparity between vaccines and vaccine logistics that requires proper attention because this helps to increase vaccine access and utilization in the country.

Conclusions: This project has demonstrated how health data captured through varying sources could be integrated and utilized by using DHIS2 as a data warehouse and visualization tool to improve public health outcomes. It also demonstrated how program managers and policymakers can use these technologies effectively when the right solutions, data integration, and presentation techniques are employed. This project may be scaled up by building capacity, adding more data sources and creating customized dashboards based on the requirements of the various stakeholders.

Keywords: Data warehouse, Surveillance, Immunization Program, DHIS2, Ethiopia

Statement on conflicts of interest: None Declared

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Journal of Health Informatics in Africa

Technical challenges and solutions adopted for sustainable implementation of hospital management information systems in a low-resource country: experience from Burundi

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Background and Purpose: The digital revolution is transforming service delivery worldwide. In the health domain, its impact is increasingly reported on health information systems, the delivery of health services, and the management of health facilities.

In 2015, Burundi launched the first version of its National Plan for the Development of Health Informatics. It started implementing a hospital management information system (HMIS) in public hospitals to digitalize the patient health record and health facility management. For hospital computerization, the OpenClinic GA software was chosen. Today, Burundi has digitalized 90% of its public hospitals and has shown significant progress in the management of health facilities. Like in other low-income countries, the implementation of HMIS in Burundi faced various technical challenges and the authors of this paper aim to share technical challenges and solutions adopted to address them.

Results: We identified 8 significant technical challenges related to (i) electricity supply, (ii) the kind of servers used, (iii) data backup, (iv) network connectivity, (v) interoperability, (vi) frequent changes in reporting needs, (vii) hardware and software management and (viii) poor end-user ICT competences. To help others move towards sustainable implementation, we also presented adopted solutions.

Conclusions: From our overview of technical challenges encountered in Burundi during HMIS digitization, we learned that this process requires more attention to technical issues to allow for more sustainable implementations.

Keywords: Challenges, solutions, sustainable, hospital management Information System, Burundi.

1 Introduction

The digital revolution is transforming the delivery of services in all areas of human life, including public health [1]. The use of digital solutions in the provision of healthcare services has a significant impact by improving the quality of care and enhancing the efficiency of healthcare providers [2].

In particular, digital tools have transformed health information systems worldwide. It has revolutionized how data is collected, exchanged, and used in clinical decision-making [3]. Indeed, wherever the information system is computerized, healthcare professionals have access to more information, enabling them to coordinate patient care, personalize management and ensure patient safety [4].

Digital tools have also revolutionized hospital management. In fact, with the availability of huge quantities of data and the possibility of monitoring offered by digital tools, hospitals have improved disease

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management, enhanced care coordination, optimized input management, and improved financial management reducing costs for the healthcare system and patients [5].

Burundi, a small country located in the East African Great Lakes region has expressed a strong political commitment to achieve universal health coverage. It has adopted the digitalization of its health sector as a means to this end [6]. In 2015, Burundi launched the first version of its National Plan for the Development of Health Informatics [7]. It started implementing a hospital management information system (HMIS) in public hospitals to digitalize patient health records and facilities management. For hospital computerization, OpenClinic GA software has been chosen. This HMIS solution integrates various functions to allow hospitals to efficiently manage and organize clinical, financial, administrative, legal, and pharmaceutical operations. It enables healthcare providers to deliver high-quality patient care while optimizing healthcare resource utilization and clinical decision-making.

Today, Burundi has digitalized ninety percent (90%) [8] of its public hospitals and has shown significant progress in the management of health facilities but still has much to do to ensure the sustainability of the systems already implemented [7].

Indeed, implementing HMIS in Burundi, like in other low-income countries, has faced various challenges and technical issues that required attention and consideration about sustainability.

The authors of this paper participated in the process of Burundian public hospital's digitalization and aim to share technical challenges and solutions adopted in addressing them.

2 Overview of technical challenges

During the implementation of digital hospital information systems in Burundi, eight main challenges have been encountered.

2.1 Electricity supply

Like in many other low-income countries, implementing hospital information systems in Burundi faced electricity supply challenges, which impaired the availability and functionality of ICT devices and access to the infrastructure [9]. Indeed, many hospitals in the country frequently experience power cuts. To cope with this situation, they have purchased power generators. Still, they mainly use them to power specific departments (neonatology, operating theatre, intensive care unit, pharmacy) rather than the complete hospital site. This impairs the usability and reliability of the installed hospital information systems.

To cope with repeated disruptions in power supply, a solar energy system dedicated to HMIS servers and hospital network components has been installed in all health facilities.

2.2 Type of servers

In the first HMIS implementations in Burundi, insufficient account was taken of the fact that the acquired servers not only needed a large amount of energy for their operation but also required a constant climatized environment for correct cooling of their processors. Energy supplies didn't always match these requirements, resulting in repeated server breakdowns. Consequently, the instability and the lack of trust in servers have been pointed out as another important challenge in implementing HMIS [10].

As a solution to this, a new kind of fanless servers with very low energy consumption (<35W) which don't require any air-conditioning has been installed in hospitals that were digitalized at a later stage. These servers are suitable for health facilities in rural areas where access to the public power grid is not guaranteed and small-scale autonomous photovoltaic systems are the only available alternative.

2.3 Data backup system

The risk of data loss exists in case the main server breaks down. In HMIS implementation in Burundian hospitals, two identical servers have been set up in each health facility: a primary server used by the end users and a secondary server for backup purposes. Initially, backups were scheduled and executed from the primary server three or four times daily. However, still, some loss of data registered between the most recent backup and the breakdown has been observed in a couple of hospitals that faced a breakdown of their primary server.

A solution to this backup challenge was found in setting up real-time data replication from the primary server to the secondary one. Both servers keep a copy of the same data at any point, and the risk of data loss has now been effectively reduced.

2.4 Network connectivity

Several authors have identified the importance of internet connectivity as an important challenge in implementing digital solutions in healthcare systems in low- and middle-income countries.

Initially, connectivity and accessibility of the HMIS were ensured by configuring two types of intranet networks (wired and wireless). But with the growing number of devices to be connected to the HMIS over the years, network extension increasingly became a challenge for hospitals. Indeed, there was the additional cost of extending the wired network whenever new devices had to be connected. It quickly became obvious that a wireless network was more capable of allowing the integration of extra workstations without any additional cost. That is why in the end, most hospitals opted for full coverage of their hospital site with a high bandwidth wireless network.

2.5 Interoperability with the national data warehouse

Interoperability is an important dimension when implementing digital solutions in the healthcare sector. Indeed, several authors have explained that interoperability allows the real-time exchange of information, improved use of data, prevention of errors related to manual input, and improved efficiency of health service producers [11,12,13].

Burundi has implemented the DHIS2 data warehouse for the National Health Information System. Each health facility is required to report its monthly health reports. Since then, users and data managers have been obliged to redundantly manually record the HMIS data in the national health data warehouse. Interoperability between the HMIS and DHIS2 has become a necessity to alleviate the work of hospital data managers and improve data quality by reducing potential manual transcription errors.

Therefore, interoperability between OpenClinic GA and DHIS2 based on the DXF2 data format has been operationalized. It is now possible for a health facility in Burundi to send monthly DHIS2 aggregate data reports automatically extracted from the HMIS to the national data warehouse.

2.6 Frequent changes in DHIS2 datasets.

At the beginning of hospital information system digitization, the Ministry of Public Health and fight against AIDS frequently modified the DHIS2 datasets to be reported. A big challenge was to keep automated aggregate data extraction scripts in the HMIS synchronized with the national DHIS2 instance. It was not only a technical problem, but also a managerial one. Indeed, software interoperability requires careful planning and organization, as changes in one application may affect the functionality or compatibility of another [14].

To address this issue, a coordination mechanism has been created and an agreement was reached on reporting templates remaining valid for at least 2 years. HMIS implementation teams must be informed prior to any changes in reporting datasets. This has been crucial for the maintenance and stability of the interoperability between DHIS2 and OpenClinic GA.

2.7 Hadware and software maintenance

The presence of dedicated IT staff in the hospital, offering technical support on hardware and software, can improve the way end users use the HMIS. In the early days of Burundian HMIS implementation, such staff has not been available, putting an important burden on the OpenClinic GA implementation teams to assist HMIS users with their everyday concerns after using the system.

To solve this, the Burundi Ministry of Health and Fight against AIDS permitted hospitals to recruit IT staff to assist users on the HMIS and to maintain the entire IT system within the hospital. This increased the user's adherence to the HMIS because receiving prompt solutions to the daily issue in using the HMIS created trust in the reliability of the solution.

Sometimes, IT staff encountered issues beyond their knowledge and required assistance from an OpenClinic GA senior technical team that was based in the capital. Therefore, a virtual private network (VPN) has been set up to provide secure access to the servers of hospitals, thus enabling remote assistance.

2.8 User's poor experience in IT

Limited IT skills can present a significant challenge in the implementation of Hospital Management Information Systems (HMIS) [15]. This may cause a lack of motivation and confidence in the use of the HMIS [16].

Burundi's public hospitals have in general employees with very limited IT skills resulting in initial difficulties in effectively utilizing the software. To address this issue, an initial training was implemented to provide hospital employees with basic IT skills before starting HMIS training. This has proven effective in boosting confidence and reducing reluctance in early usage of the HMIS.

Additionally, the Burundian Ministry of Health developed a continuous training program known as "Certification in Applied Health Informatics", aiming to enhance the understanding and utilization of the HMIS by healthcare professionals while providing a broader insight in the national digital health ecosystem.

3 Conclusion

The Burundian health system has achieved substantial progress in HMIS implementation. Today, more than ninety percent of hospitals have been digitalized. From our overview of technical challenges encountered in Burundi during HMIS implementation which are the electricity supply, the type of servers, the data backup system, the network connectivity, the interoperability with the national data warehouse, the frequent changes in DHIS2 reporting templates, the hardware and software maintenance and the end user's limited IT skills, we learned that more attention to technical issues is required in order to achieve more sustainable digital hospital systems.

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Journal of Health Informatics in Africa

Data Integration OPENLDR-EPTS

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Background and Purpose: The data integration project was a strategy designed with the goal of improving the turnaround time when requesting viral load analysis and reduce the manual data input typing errors. Before the data integration between the national laboratory data repository (OpenLDR) and the Electronic Patient Tracking System (EPTS), data relating to patient outcomes were extracted from DISALINK by printing the laboratory test result and then manually inserted into the patient record in EPTS. This process led to a high response time between test requests and results being available in EPTS, as well as errors.

Methods: Implementation of the data integration mechanism focused initially on province of Zambezia. National expansion of the integration project, involving multiple additional partners to ensure a coordinated effort.

Results: After the integration, one more stage was included in the process, in this new scenario the need for an automated lab result insertion into the EPTS was the main goal.

The data are sent in real-time to the staging server which automatically synchronizes and inserts the results into the EPTS.

With the integration of OPENLDR and EPTS:

- Reduction in turnaround time between test requests and availability of results in EPTS.
- Decreased data insertion errors.
- Improvement in the quality of public health services provided in Mozambique

Conclusions: The integration of the Open Laboratory Data Repository (OPENLDR) with the Electronic Patient Tracking System (EPTS) in Mozambique facilitated through collaboration between various organizations, has yielded positive outcomes.

Keywords: integration, laboratory, repository

1 Introduction

The data integration project between OPENLDR and EPTS was carried out in Zambezia province between 2019 and 2022. The province of Zambezia is in the northern part of Mozambique, with a territorial extension of 103 478 km² and approximately 5,1 million population density, this is considered the most populous province in Mozambique. The province has 294 public health units and 2 public reference laboratories equipped with health information systems for clinical and laboratory areas.

The data integration project was a strategy designed by the institutions CDC (Center for Disease Control), APHL (entity responsible for the laboratory information system), and FGH (entity responsible for the health information system for the clinical area) with the goal of improving the turnaround time when requesting viral load analysis and reduce the manual data input typing errors. Before the data integration between the Open Laboratory Data Repository (OPENLDR) and the Electronic Patient Tracking System (EPTS), data relating to patient outcomes were extracted from DISALINK by printing the laboratory test result on plain A4 paper and then manually inserted into the patient record in EPTS. This process led to a high response time between test requests and results being available in EPTS, as well as opening spaces for typing errors.

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Through joint efforts between the Centers for Disease Control and Prevention (CDC), the Association of Public Health Laboratories (APHL), and Friends in Global Health (FGH) organizations, it was possible to develop a mechanism capable of providing data integration between OPENLDR and the EPTS systems. The integration started in the Mozambique province of Zambezia with only the health facilities on behalf of FGH, thankfully, the experience allowed for a national expansion which is now involving much more partners, among them are, Ariel Glaser Pediatric AIDS Foundation (AGPAF), Elizabeth Glaser Pediatric AIDS Foundation (EGPAF), International Center for AIDS Care and Treatment Programs (ICAP), Centro de Colaboração em Saúde (CCS), European Commission Humanitarian Aid & Civil Protection (ECHO), Johns Hopkins Program for International Education in Gynecology and Obstetrics (JHPIEGO)

As a result of this integration, it was possible to reduce turnaround time as well as reduce data insertion errors, thus improving the public health services provided in (Mozambique).

1.1 Objectives

1. Develop a mechanism for data integration between the Open Laboratory Data Repository (OPENLDR) and the Electronic Patient Tracking System (EPTS).
2. Reduce response time between test requests and results in EPTS.
3. Minimize typing errors associated with manual data insertion.

2 Materials and methods

The study design employed in this project was experimental, due to its specifications and goals aligned with the expected result as stated below.

- Collaborative efforts between the Centers for Disease Control and Prevention (CDC), the Association of Public Health Laboratories (APHL), and Friends in Global Health (FGH) organizations.
- Implementation of the data integration mechanism in the Mozambique province of Zambezia, initially involving health facilities on behalf of FGH.
- National expansion of the integration project, involving additional partners such as Ariel Glaser Pediatric AIDS Foundation (AGPAF), Elizabeth Glaser Pediatric AIDS Foundation (EGPAF), International Center for AIDS Care and Treatment Programs (ICAP), Centro de Colaboração em Saúde (CCS), European Commission Humanitarian Aid & Civil Protection (ECHO), and Johns Hopkins Program for International Education in Gynecology and Obstetrics (JHPIEGO).

2.1 Mode of operation before integration

Before the integration, when a patient made a visit to the Health Facility (HF) and a viral load test was required, the flow of work was as follows:

1. The Doctor or the nurse had to manually fill in a paper request form (FSR) with the patient information and the required laboratory analysis.
2. The Laboratory had to collect the sample and insert the data of the FSR into the DISA (LIS) and the same FSR data was also inserted into the EPTS.
3. The request form and the sample were sent to the reference laboratory (DISALAB) for the sample to be analyzed.
4. When the sample arrived at the reference laboratory all work protocols were verified and the sample was analyzed.
5. When the test result was available at DISALAB, it was automatically sent to DISALINK and OPENLDR.
6. When the result was available at the DISALINK, it was printed out and delivered to the EPTS to be manually inserted into the previously registered information at step #2.

Fig. 1 describes the scenario before the integration.

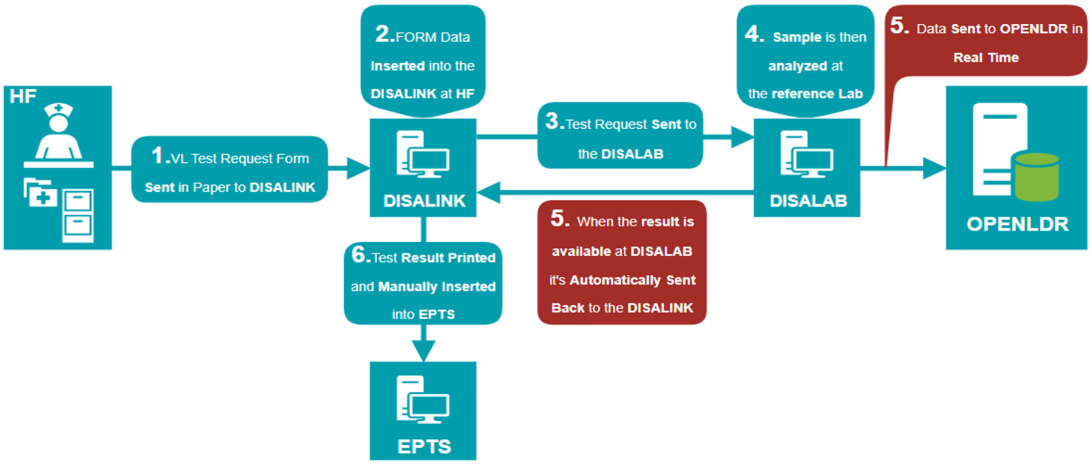

Fig. 1 - Vl and EID lab tests request and result flow before the OpenLDR => EPTS integration

2.2 Mode of operation after implementing the solution

After the integration, one more stage was included in the process, in this new scenario the need for an automated lab result insertion into the EPTS was the main goal.

Following the previous scenario mode of operation from step #5, now the data is sent in real-time to the staging server which automatically synchronizes and inserts the results into the EPTS as shown in

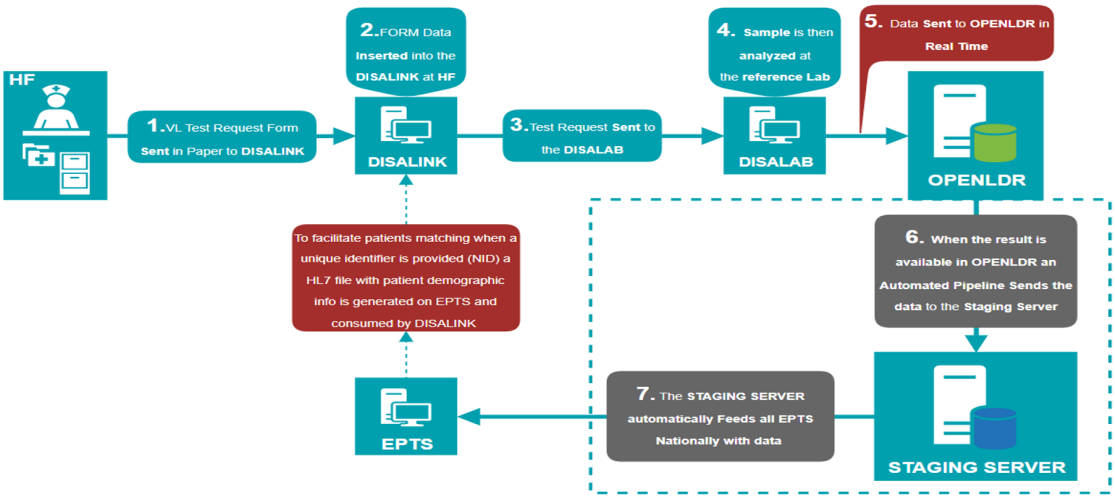

Fig.

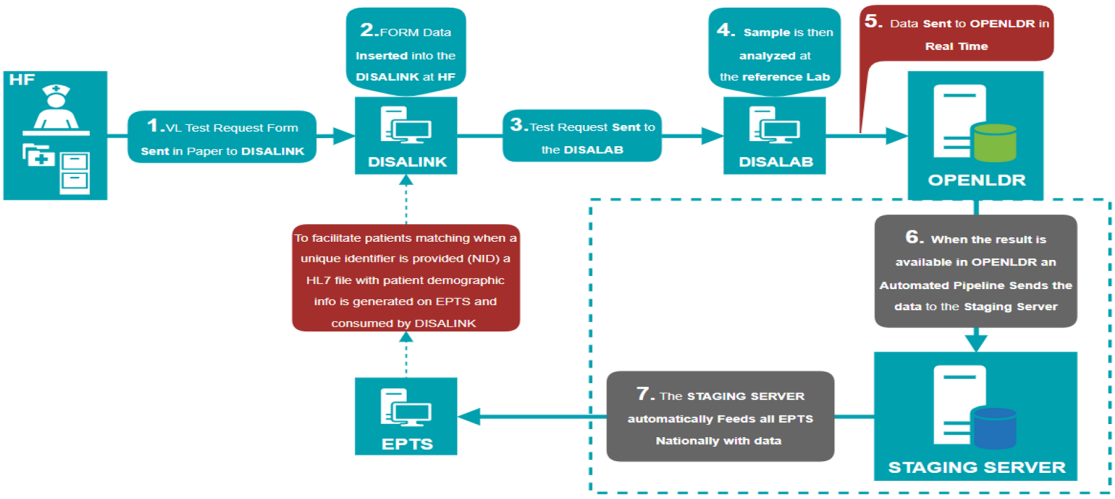

Fig. 2- Vl and EID lab tests request and result flow after the OpenLDR => EPTS integration

3 Results

With the integration of OPENLDR and EPTS:

- Reduction in turnaround time between test requests and availability of results in EPTS.
- Decreased data insertion errors.
- Improvement in the quality of public health services provided in Mozambique.

4 Discussion

The integration of the Open Laboratory Data Repository (OPENLDR) with the Electronic Patient Tracking System (EPTS) in Mozambique facilitated through collaboration between various organizations, has yielded positive outcomes. The implementation of the data integration mechanism resulted in reduced turnaround time and decreased data insertion errors, leading to improved public health services.

Journal of Health Informatics in Africa

Informatics Savvy Health Organization (ISHO) Assessments: A Pathway for Health Informatics Maturity Across Africa

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Background and Purpose: As digitization of health information systems (HIS) advances, countries work toward improved digital health infrastructure and health informatics maturity. The Informatics-Savvy Health Organization (ISHO) assessment aims to gather HIS owners and leaders, build consensus on the state of informatics capabilities, and establish priorities for investment. Implementers are collaborating with CDC and Ministries of Heath in Ethiopia, Nigeria, and Zambia to conduct assessments in 2023.
Methods: ISHO addresses: 1) vision, policy, and governance; 2) skilled workforce; and 3) effective information systems. ISHO tools allow rating of informatics capabilities by maturity level. Site and participant sampling is purposive, gathering key informants to score items, discuss, and agree on evidence-based rankings. ISHO culminates in a national-level results-validation and action-planning workshop.
Results: In Zambia, I-TECH and PATH implemented the ISHO assessment in April 2023. Data collection took longer than anticipated due to the large number of items in the tool and the need for both individual and group consensus scoring. Nigeria's Federal Ministry of Health (FMOH) convened 26 participants in a three-day workshop to review the ISHO tool, adapt items for local relevance, plan implementation. The full ISHO assessments in both countries are pending.
Conclusions: The Zambia experience demonstrated ways to improve the ISHO assessment, e.g., including stakeholders in planning the assessment, notifying study sites and sharing the ISHO tools in advance of visits, and streamlining the number of items. The Nigeria experience demonstrated local ownership of the ISHO process and the value of a participatory process involving decision makers who can translate findings into action.

Keywords: Digital health, Health Informatics, Framework, Assessment, Maturity, Sustainability.

1 Introduction

As data modernization and digitization trends upwards, public health agencies are under pressure to adapt public health practice accordingly. Aligning with the global informatics-savvy trend entails a resource shift towards establishing and leveraging electronic health records and health information exchanges to effectively use health information [1]. Recent disease response efforts, triggered by the outbreak of COVID-19, the Ebola virus, and other diseases, have heightened the urgency to further strengthen and scale up digital health infrastructure. However, low- and middle-income countries are facing barriers to the scale

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and efficacy of digital health informatics, ranging from ineffective and incongruent information systems, workforce capacity limitations, data security and reliability concerns, and lack of governance. All the above exacerbate the difficulty in establishing sustainability of health informatics interventions in an environment of varied maturity of health information systems (HIS) [2].

In a limited health informatics ecosystem, how can low- and middle-income countries chart a path towards improved digital health infrastructure and health informatics maturity? This work in progress paper seeks to share observations from the application of the Informatics-Savvy Health Organization (ISHO) framework and strategy to inform a country's digital health development. This paper will describe the development of tools to support planning and programmatic development, as well as the adaptation and/or use of those tools in three United States President's Emergency Plan for AIDS Relief (PEPFAR)-supported countries. The goal is to share learnings on ISHO implementation thus far, to inform future use in interested countries.

1.1 The ISHO Framework

The Informatics-Savvy Health Organization (ISHO) concept was originally developed by the Public Health Informatics Institute (PHII), with the understanding that *"public health agencies need a clear informatics vision and strategy that include workforce development and robust, interoperable information systems"* [3]. The ISHO concept has since been adapted for the global health context by the United States President's Emergency Plan for AIDS Relief (PEPFAR)-funded Technical Assistance Platform (TAP) Project and has direct applications for data modernization.

The ISHO Framework represents an informatics-savvy organisation – or country – as being supported by the three equally critical pillars of 1) vision, policy and governance, 2) skilled workforce, and 3) effective information systems, as illustrated in Figure 1 below.

ISHOs, when functioning optimally, obtain, effectively use, and securely exchange information electronically to improve public health practice and population health outcomes.

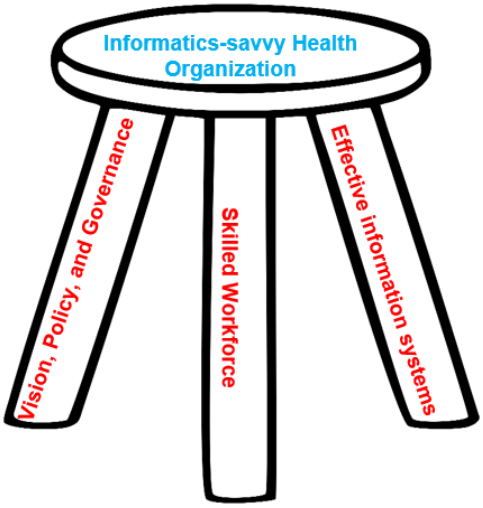

Figure 1: Illustration of the ISHO Framework

1.2 A Country-driven Process

For the ISHO strategy and tools to be optimally effective, it is critical for their application to be pursued not only with the support of country leadership, but through country ownership. In practice, this means that country digital health leadership, ideally at the federal/central level of the Ministry of Health (MOH), should buy into the concept of the ISHO and assume oversight of ISHO-related activity implementation. Implementation with MOH oversight may then include a diverse set of stakeholders and HIS implementing partners, including government agencies (Ministry of ICT etc.) and international/foreign government agencies (e.g., CDC, USAID, and others).

MOH leadership of ISHO implementation will enable relevant stakeholder participation in planned activities. It will also set the precedent for MOH leadership of follow-on activities, enabling the sustainability of ISHO framework application through a country-driven process.

2 Materials and methods

The Informatics-Savvy Health Organisation (ISHO) assessment assists countries in strategic governance of health information systems by informing national, sub-national, and facility level planning and programmatic development. The goal of the ISHO assessment process is to bring together stakeholders who own and lead health information systems and build group consensus on the current state of informatics capabilities at every level/in targeted segments of the healthcare system, as well as on priorities for the future.

Each capability in the ISHO assessment (vision, policy, and governance; skilled workforce; and effective information systems) can be rated as (1) absent; (2) initial; (3) managed; (4) defined; (5) measured; and (6) optimised. The ISHO assessment establishes a systematic basis of measurement for identifying gaps, setting goals for future levels of maturity, and informing the development of improvement plans to realise the next stage of progress toward a more mature and sustainable ISHO. The ISHO assessment includes above site-level and site-level assessment tools. The above site-level assessment takes place in districts, regions/provinces/states, or in national-level organisations, whereas the site-level assessment takes place within health facilities. The above site-level tool has a total of 31 items, while the site-level tool has 58 items, with descriptors of maturity for each level of capability. The tools were designed with the intent to limit the items per tool to improve acceptability and efficiency in capturing data and thereby aid in informing decision-making.

Since 2019, the US Centers for Disease Control and Prevention (CDC) has used ISHO in expedited assessments carried out by 3-5 key informants during informatics professional development workshops, or by individual staff members. More recently, CDC has advanced the use of ISHO in in-depth assessments, to increase national engagement in ISHO for strategic planning of health information systems. During an in-depth ISHO assessment, key informants at each level gather to review and discuss the ISHO assessment tool, engaging in individual rating of each item as well as group discussion to arrive at consensus on the current maturity status. Sampling of participants and sites is purposive. For above site-level assessments, approximately 20-40 key informants or subject matter experts engage in the data collection (scoring) process. For site-level assessment, 5-20 participants including managerial, technical, and frontline staff may participate in each assessment. For each item, participants are encouraged to document evidence to justify the consensus ratings.

The culmination of the ISHO assessment process is a national-level validation workshop to review summary results, validate the final consensus scores, and discuss priorities for future action planning. The development and application of the ISHO assessment framework has been supported through funding from CDC to PATH and its consortium partners University of North Carolina / Measure Evaluation and University of Washington / Digital Initiative Group at I-TECH. The PATH consortium supported completion of an ISHO assessment in Zambia in April - May 2023 and is currently planning ISHO assessments in Ethiopia and Nigeria.

3 Results

In Zambia, the ISHO in-depth assessment involved four above-site and 23 site level sites. At the time of this submission, data collection was ongoing with the expectation of being completed by May 15, 2023, hence a summary of maturity scores was not yet available. The assessment process and tools were piloted at three facilities: one above site-level and two at site level. During the initial pilot of the in-depth ISHO assessment process in Zambia, data collection at the site level took longer than anticipated due to the large number of items in the tool, as well as the need for scoring by individuals and by group consensus. Process improvements identified included improved stakeholder sensitization and involvement in planning the assessment, ensuring that sites receive timely notification about their participation and sharing the ISHO

tools with participating sites in advance of site visits. A recommendation was to streamline the set of items to avoid participant fatigue and improve efficiency.

Planning for ISHO assessments in Zambia, Ethiopia, and Nigeria included the development of country specific evaluation protocols for review by local and international ethics committees, and orientation of stakeholders to the methodology and tools. In Nigeria, the Federal Ministry of Health convened a two-stage workshop to develop local capacity and drive ISHO ownership, as well as establish governance structures to drive the ISHO assessment and the utilisation of findings for national and sub-national HIS improvements. The meeting had various stakeholders in attendance such as those in the field of Health informatics, disease programmes including HIV, tuberculosis, and health systems strengthening. The first session was a three-day workshop that included 32 participants and the following workshop had a combined 42 participants: 27 in-person and an average of 25 online, over five days. The Protocol is undergoing ethical review by the National Health Research and Ethics committee in Nigeria. In Ethiopia, a team from MOH, CDC, and HIS partners were engaged in the protocol development and in refining the generic ISHO assessment tools to align with the local context. There is a plan to provide two days training (mid-May 2023) on the ISHO framework and the assessment tools to participants from MOH, University of Gondar (UoG), and ICAP at Columbia University. During the training, MOH and UoG will develop the above site and site level assessment work plan. The above site and site level assessment in Ethiopia is thought to be completed within 6 weeks.

4 Discussion

As an initial pilot of the in-depth ISHO assessment process, the Zambia experience produced many lessons learned. To improve the process, when planning for the assessment there is a need to engage appropriate stakeholders working with the MOH in implementing ehealth/digital health systems as targeted key informants. Several ehealth platforms are used that are specific to a health system: laboratory, pharmacy, outpatients, maternity, etc. For the sustainability and adoption of the results, and the use of the tools post-assessment, it is critical to involve both public and private implementing partners to ensure buy-in as well as successful and generalizable information. Second, to improve efficiency, communication to participating sites and participants should be done at least two weeks prior to visits, clarifying the specific group of participants required to participate. Sites should provide feedback on the receipt of communication, identify a site-based contact person, and confirm through phone calls to set up appointments. Third, consent forms and assessment tools should be sent to the sites prior to the assessment, to enable participants to familiarise themselves and thereby facilitate the efficient completion of responses in the tools during the assessment. Fourth, use of electronic tools is essential - there is a need to build/employ an electronic data capture tool, such as SDMS or REDCap, to improve efficiency, accuracy and expedite data capture, management and analysis. Lastly, the site-level assessment tool generally has more core essential elements than the above site-level tool, and hence requires more time to complete. Prioritising and grouping participants based on their knowledge and completing the tool per ISHO pillar improves both time efficiency and the objective review of questions and scoring.

The Nigeria experience demonstrated the value of Ministry of Health ownership and buy-in of the ISHO assessment process. This buy-in to the ISHO framework underscores that its value is derived, not from externally generated system maturity scores, but from a participatory process that involves a country's decision makers collaboratively assessing the evidence of the country system's maturity so that they can use the deliberation for prioritisation and action planning. The actions in Nigeria demonstrate support from donors, various partners and non-governmental organisations.

The Ethiopia experience demonstrated that the generic assessment tools need to be adapted to the local context. Furthermore, the active engagement of MOH and a government university are thought to impart local ownership and continuity of the activity.

5 Conclusion

Data and information are critical for mitigating threats to public health. Developing realistic digital health strategies and having the skills and methods to achieve them requires effective application of public health informatics principles and methods. No amount of advanced technology alone can effectively detect, prevent, or mitigate public health threats. That requires the most valuable resource of all: people with the right skills. The human element includes steadfast leadership to provide a vision and supporting governance, and a workforce willing to learn new ways of using information and of sharing what information they have with others. The ISHO framework supports a rigorous process for identifying and prioritising capabilities related to using information as a strategic organisational asset, ensuring an appropriate balance of attention to governance, workforce, and technology.

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Statement on conflicts of interest

We have no conflicts of interest to report in submitting this work in progress paper.

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Journal of Health Informatics in Africa

Impactful approach to identify national digital health investments for scale, with an aim towards sustainability

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1 Introduction

In order to achieve a positive impact on a country's health information systems ecosystem, investments need to be directed to impactful and sustainable digital heath solutions. For this reason it's important to carefully and strategically assess a country's HIS ecosystem to identify the right digital health investments. The Millennium Corporation Challenge (MCC) [1] identifies countries that have a healthy economic growth trajectory and invests in those countries' sectors that are driving the growth. In Lesotho, the information communications technology (ICT) and digital health have been identified as some of those key sectors, for MCC investment. In 2021, RTI International [2] and the National University of Lesotho (NUL) [3] worked alongside MCC, and the Lesotho Millennium Development Authority (LMDA) to plan an ICT assessment that would help identify key areas for scale in sectors driving technological growth, with the goal of identifying modern, effective digital health solutions for scale in a timely and cost-effective manner, and improving Lesotho's ICT connectivity, to improve service in the health sector. All findings and recommendations are documented in [4].

2 Materials and methods

Our ICT assessment started during the spur of the Covid19 pandemic. As a result, the methodology used to complete the ICT assessment required creative execution. With a nationally focused assessment, targeting the health sector, network coverage, and health information systems at the community, district, and national levels, our assessment included the following phases: 1) Literature review; 2) District site visits (assessments of district, health facilities, and community councils); 3) National office interviews (interviews with management and assessment of some national offices); and 4) Topical discussions (discussions around key topics with multiple identified stakeholders in Lesotho health and ICT).

The literature review served as a situation awareness exercise to understand the extent to which the government entities have contributed to the ICT and digital health investments in-country. It served as a basis to target relevant Government of Lesotho (GOL) entities and partners for further investigation into the use of, and investment, in ICT and technological solutions. Additionally, telecommunications and mobile network provider coverage maps provided insights into the level of mobile network coverage across each district, and future plans for the expansion of the Lesotho Government Data Network (LGDN) [4].

At the national level, the Ministry of Health (MOH) [5] was the entity of priority, alongside their implementing partners and donors (PEPFAR [6], Global Fund [7], and WHO [8]). Other government entities with key ICT investments and authority over components of the Lesotho ICT sector were also consulted, such as the Ministry of Communications, Science, and Technology [9], the Ministry of Home Affairs [10], and the Ministry of Agriculture [11]. Interviews were held with health management information systems, and the ICT team leads, along with the national laboratory and pharmacy focal points. Efforts were made to learn about existing HIS enterprise architecture; ICT expert support structures at the

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subnational level; LGDN; and digital health investments. The national electronic health records systems, laboratory information systems, and pharmaceutical systems were prioritized.

At the sub-national level, district health teams, community councils, and health facilities were prioritized. Not being able to venture into every district and every health facility in the country, and to be economical, while ensuring valid results, our sampling methodology directed us to focus on seven (7) out of the ten (10) districts in Lesotho. The selected districts represented urban and rural based health facilities, which characteristically tend to have a different concentration of human resource capacity, connectivity, and infrastructure. Consultations at the local level included an inventory of ICT equipments and digital health investments, assessment of network connectivity, and the determination of ICT support capacity. Exploration at the local level allowed us to interact with the Ministry of Local Government and Chieftainship [12] at the district and community levels, and this offered key insights into the planned expansion of ICT network support across the health system.

3 Results

Our overarching findings illustrated a plethora of opportunities to invest in the Lesotho ICT sector [4]. In particular, the findings indicated the key areas for investment to improve ICT infrastructure in support of expanding network accessibility, and where to prioritize optimization and scale of sustainable digital health solutions. Additionally, It was revealed that ICT infrastructure improvements also require tackling improvements to governance practices and policies, and ICT support and maintenance especially at the lowest level of the health system. Among others, expansion of network coverage, and scaling of national digital health global goods including the national electronic health record system, national health information system, pharmaceutical system, and general optimization of the national health information exchange (all key components of an HIS ecosystem) should be prioritized.

Also, it is important to ensure that where existing digital health implementations are successful, future investments must leverage and build on them, rather than create something new. This helps to ensure that resources are adequately used.

Additionally, it's important that local capacity is involved throughout planning and implementation, and the government leads the coordination of investments.

Lastly, all interventions should make a collective effort to engage existing donors and implementing partners, to ensure the adequate use and sharing of resources allocated to ICT infrastructure strengthening and digital health scale.

4 Discussion

An assessment approach involving an in-depth literature review, followed by interviews with key informants, and targeted site visits, offers a stepwise approach for a deep dive into understanding the state of ICT infrastructure, and HIS ecosystem in a country. Gaining situation awareness through a literature review offers a foundational understanding of the current state, and data from the literature review can be further validated by site visits and key informant interviews.

Additionally, a true appreciation of digital investments made across a government, and health system in particular, requires a holistic and targeted focus on key government stakeholders at both the national and local level, as well as input from implementing partners performing HIS strengthening and service providers leading network and general ICT expansion in a country.

A holistic and targeted approach to a digital health assessment is key to investing in sustainable digital health. Sustainability is an important agenda for developing countries that have limited resources and rely on foreign funding.

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Journal of Health Informatics in Africa

Leveraging on existing laboratory Information systems to enhance surveillance and cross border data sharing - Ebola Virus Disease testing in Kenya

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Background and Purpose: Laboratory data plays a key role in supporting public health surveillance activities. Availability of these data can determine the appropriate response to an outbreak or public health emergency. Linking laboratory with surveillance data effectively and in a timely manner is therefore critical.
Methods: Rather than introducing new tools and technologies, the technical team focused on assessing systems already in use and enhancing them. The team also emphasized private sector laboratories which often conduct large volumes of testing and established tools for capturing data from these sites. Thirdly the team adopted a best practices approach that involves two-way data flow from surveillance to laboratories and vice versa.
Results: The teams leveraged existing solutions and was able to provide laboratory and surveillance data exchange in real-time within one week. No new systems were deployed.
Conclusions: Integration of surveillance and laboratory systems ensured the availability of critical data to the surveillance team and the use of existing systems promoted sustainability and scalability.

Keywords: laboratory, exchange, integration

1 Introduction

Laboratory data plays a key role in supporting public health surveillance activities. Availability of laboratory results in a timely manner is critical in the control of the spread of diseases of public health concern. Following the outbreak of Ebola virus Disease (EVD) in neighboring countries, Kenya's emergency response team was activated to establish relevant surveillance measures for better preparedness. EVD testing and detection capacity is limited globally and within Kenya. With EVD being a highly contagious and deadly disease, effective linkage between the different systems used by surveillance and laboratory departments in the Ministry of Health (MOH) was critical to ensure that diagnostic data were available in time to inform rapid action. This paper presents the approach to linking surveillance and laboratory information systems in Kenya as part of the preparedness for EVD.

2 Materials and methods

Technical teams from the MOH and other partners came together to review the existing surveillance systems, Jitenge+ and the NPHL laboratory repository 'Lab Repository' that were capturing data on suspected EVD cases. The teams investigated bi-directional sharing of data: 1) data on suspect EVD cases from Jitenge+ to the LIMS to initiate testing and 2) laboratory results for the suspect EVD cases from LIMS to Jitenge+ for appropriate case management. The technical teams agreed on a step wise approach. First,

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the technical team made modifications to Jitenge+ to capture laboratory-specific data elements. Next, the team used the interoperability layer and with REST APIs integrated the Lab Repository and Jitenge+ to allow for automated data exchange between the two systems; with Jitenge+ pushing the Sample ID to the LIMS and pulling results from the LIMS. This integration happened at the national reference laboratory. With the increasing capacity of laboratories to test for EVD, the team focused on enhancing Jitenge+ to generate a unique sample ID for a suspected case. This sample ID was shared with the LIMS through the interoperability layer using REST APIs, thus allowing for testing data captured in the LIMS to be associated with this sample ID. Sharing the test results back with Jitenge+ was also made possible by the use of this Sample ID. Taking into account laboratories that use different LIMS, the team provided for upload of a structured excel template to the laboratory repository portal.

3 Results

Having integrated the two systems, it was possible for the surveillance and the laboratory systems to exchange data on a real-time basis. With the testing capacities of the laboratories growing, the provision of both automated and semi-automated means to relay results to the laboratory repository ensured availability of the data to the surveillance system. The most important aspect of this work was the reduction of time taken to have the system up and running. In total, it took the team less than 1 week to have everything up and running and preparing for the training of the county teams. This is drastic time reduction could be attributed to the implementation of an integration layer that did speed up the systems integration effort and testing.

A key aspect of this work was that the team was able to leverage two existing solutions and make enhancements to them to support needs of EVD surveillance: a tool that had been developed to support contact tracing during the COVID-19 pandemic and the LIMS that has been in use by national reference laboratories since 2009. No new systems were deployed during this process.

4 Discussion

Integration of the surveillance and the laboratory systems ensured availability of critical diagnostics data to the surveillance team to make critical patient care decisions as well as monitor the disease outbreak trends. The use of existing systems to facilitate this also promotes sustainability of such systems and allows for further scalability of the systems to support public health interventions in the country.

Journal of Health Informatics in Africa

Implementation of Specimen Biorepository Data Information System in supporting public health research in a resource limited setting

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Background and Purpose: The Kenya Medical Research Institute is tasked with long term sample storage in -80C freezers that have traditionally relied on paper systems and Excel spreadsheets. This made it impossible to actually track samples, determine sample volume and have accurate traceability. This paper explores the implementation of an electronic sample bio-repository at the KEMRI DLSP laboratories to facilitate efficient and correct sample storage and retrieval.
Methods: APHL led the development of a sample biorepository system for use by the KEMRI DLSP laboratories using the existing Microsoft .NET framework. Legacy sample data that was previously stored in Excel documents was uploaded to the new system. The sample archival team from the laboratories were trained by APHL staff and the system rolled out for use.
Results: Retrieval of samples from the freezers is faster and has resulted in improved reliability of the overall process; currently this process takes less than 5 minutes as compared to more than 20 minutes prior to system implementation. Users can determine sample volume through the system prior to sample retrieval. Migration of the data from spreadsheets to the electronic system has also helped streamline sample data management.
Conclusions: The sample archival system at KEMRI DLSP facilitates both sample storage and retrieval, hence promoting the generation of diagnostic data to inform research while maintaining the integrity of the sample chain of custody. It also enables the laboratory to utilize resources optimally.

Keywords: biorepository, traceability, storage

1 Introduction

The Kenya Medical Research Institute - Diagnostics Laboratory Support Program (KEMRI-DLSP) support research activities for several projects by conducting diagnostic tests on the samples collected. After the initial testing, these samples are stored for further testing as per study protocols. Over time, more than 25 ultra-low -80 C freezers in the laboratory are overflowing with samples collected over a decade in addition to several thousand collected during the SARS-CoV 2 pandemic. KEMRI laboratories had a laborious manual system involving paper and spreadsheets to track sample storage locations making it challenging to update records regularly and maintain accuracy. The result was long turnaround times in sample retrieval, and the inability to track sample volumes precisely. This paper explores the implementation of an electronic sample bio-repository at the KEMRI DLSP laboratories to facilitate efficient and correct sample storage and retrieval.

2 Materials and methods

APHL led the development of a sample biorepository system for use by the KEMRI DLSP laboratories using the existing Microsoft .NET framework. Legacy sample data that was previously stored in Excel

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documents was uploaded to the new system. The sample archival team from the laboratories were trained by APHL staff and the system rolled out for use. From development to deployment, the process took six months. The sample archival team, operating in the role of super users, trained all other laboratory staff on making sample storage requests from the system. A request involves the laboratory staff completing information on the storage request template by specifying the sample information (unique sample ID, study associated with the sample, sample volume etc.) and the box position of the sample. On approval of a storage request, the archivist allocates a freezer, drawer, rack, and the storage location of the box of samples to be archived, then uses this designated location as a guide to store the box in the allocated position. To retrieve a sample, the archivist searches the sample ID on the system. The system returns the sample storage information, including the freezer, drawer, rack, box number and box position of the sample storage location

3 Results

Through the use of this system, an archivist can view available freezer space to determine appropriate sample location. Retrieval of samples from the freezers is faster and has resulted in improved reliability of the overall process as laboratory staff can be assured that they will be able to find the sample in the location specified by the repository system. Currently this process takes less than 5 minutes as compared to more than 20 minutes prior to system implementation. Users can determine sample volume through the system prior to sample retrieval and this improves efficiency. Migration of the data from spreadsheets to the electronic system has also helped streamline sample data management, reducing the workload of the archival staff involving manual maintenance of these records. The new system has also facilitated sample chain of custody traceability as all transactions related to a sample can be easily audited by pulling the sample history from the system. Bulk search of samples using the unique sample IDs has also made sample retrieval easier, supporting additional testing that may be required on these samples.

4 Discussion

Being able to effectively and efficiently trace data back to the diagnostics and actual sample is important in promoting evidence-based research. Putting accurate and reliable systems in place that can promote backward traceability of such data as well as maintaining proper sample chain of custody is critical to supporting a key business process of laboratories such as KEMRI. The sample archival system at KEMRI DLSP facilitates both sample storage and retrieval, hence promoting the generation of diagnostic data to inform research while maintaining the integrity of the sample chain of custody. It also enables the laboratory to utilize resources optimally. Ultra-low freezers are costly to acquire and maintain. Inefficient use, such as frequent opening of freezers to search for samples, can impact the longevity of samples and lower freezer life span. The bio repository addressed both these risks by enabling laboratory staff to efficiently retrieve samples.

Journal of Health Informatics in Africa

Adopting the Digital Adaptation Kit Approach as the Standard for Documenting, Expressing and Communicating Technical Requirements for Digital Health Software Development; A Case Study

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Abstract. Background and purpose: The World Health Organization (WHO) develops guidelines and recommendations that guide and inform the implementation of evidence based clinical approaches and policies aimed at advancing public health. While the guidelines developed at the WHO level represent a global standard and credible information source that can be contextualized to fit each country's health setting, their interpretation varies based on several factors resulting in disparities in their implementation. As efforts and investments continue to be made towards digital-first health systems, it is vital to streamline the interpretation of clinical guidelines to ensure the digital solutions developed advance the provision of evidence based care by promoting adherence to clinical guidelines.
In efforts to improve the software development process by streamlining the interpretation of technical requirements and clinical guidelines, IntelliSOFT Consulting Limited, a health IT company that focuses on developing digital health solutions for low and middle income countries has formally adopted and adapted Digital Adaptation Kits (DAK) approach as the standard for technical requirements communication and documentation. The DAKs are part of the Standards-based, Machine-readable, Adaptive, Requirements-based and Testable (SMART) guidelines developed by WHO. The goal is to improve the organization's digital health software applications development process based on the rationale that the adapted DAKs will improve the efficiency and effectiveness of the digital health solution development process, increase the solution's fidelity to care guidelines, and overall reduce costs of solution development.
Methods: This case study outlines the initial steps in the transformation process which includes the adoption of the DAK approach for technical documentation and requirements interpretation. The first step of this process entailed company wide capacity building on the WHO SMART guidelines with a keen focus on the digital adaptation kits along with the creation of a local IntelliSOFT DAK template customizable for the various solutions developed and implemented by the company. The next phase of this transformation process will entail the active practice of the DAK approach with close monitoring to check for improvements in the development process in terms of the quality of products developed and the time taken in understanding requirements.
Results: Along with the IntelliSOFT DAK template customizable for different projects, a key output of the initial stage of the transformation process at IntelliSOFT also includes a roadmap for the adoption of the DAKs interspersed with monitoring and evaluation exercises to be done every three months or after the completion of each project in which the DAKs are used whichever comes first. Lessons learned in the process will be shared with the SMART guidelines community of practice in various fora.
Conclusions: The development of digital health solutions that are fit for purpose is pegged on the accurate interpretation of clinical guidelines and technical requirements to provide a clear understanding to all project stakeholders. The DAKs offer a standard and demystified approach for requirements interpretation that has the potential to make the project inception phase more seamless and quicken project take-off. Adoption of the DAK approach is one of IntelliSOFT's steps towards transformation as the company is in a steady growth and scale-up phase. It is anticipated that the DAK approach compared with previous methods for technical requirements documentation including the SRS will result in better and more efficient digital health solution development.

Keywords: World Health Organization(WHO), SMART Guidelines, Digital Adaptation Kit(DAK), Digital Health.

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1 Introduction

The World Health Organization (WHO) develops guidelines (World Health Organization. 2014) and recommendations to assist policy-makers and clinicians in making informed decisions about clinical practice and public health policies. The guidelines represent a global standard and credible information sources that can be contextualized to fit each country's health setting (Lancet Digit Health. 2021). However, governments and technology partners may experience challenges in translating and incorporating these guidelines into digital systems. The SMART guidelines are reusable digital health components that offer a five-step approach to enhance the adoption and implementation of best clinical and data practices (World Health Organization. 2019). They were developed to help interpret, standardize and streamline technical WHO guidelines thus preventing errors arising from varying interpretations, avoiding duplication of efforts and enhancing applicability (World Health Organization. 2020).

Digital Adaptation Kits (DAKs) see figure 1 below; are part of the SMART guidelines initiative and include data and health content consistent with WHO's recommendations, generically applicable to digital systems (World Health Organization. (2022). They are software-neutral, operational, and structured documentation based on WHO clinical health system and data use recommendations to systematically and transparently inform the design of digital systems (Glob Health Sci Pract. (2022). Components include: Linked health interventions and recommendations, Personas, User scenarios, Business processes and workflows, Core data elements mapped to standard terminology codes (e.g. ICD), decision support, programme indicators and functional and non-functional requirements.

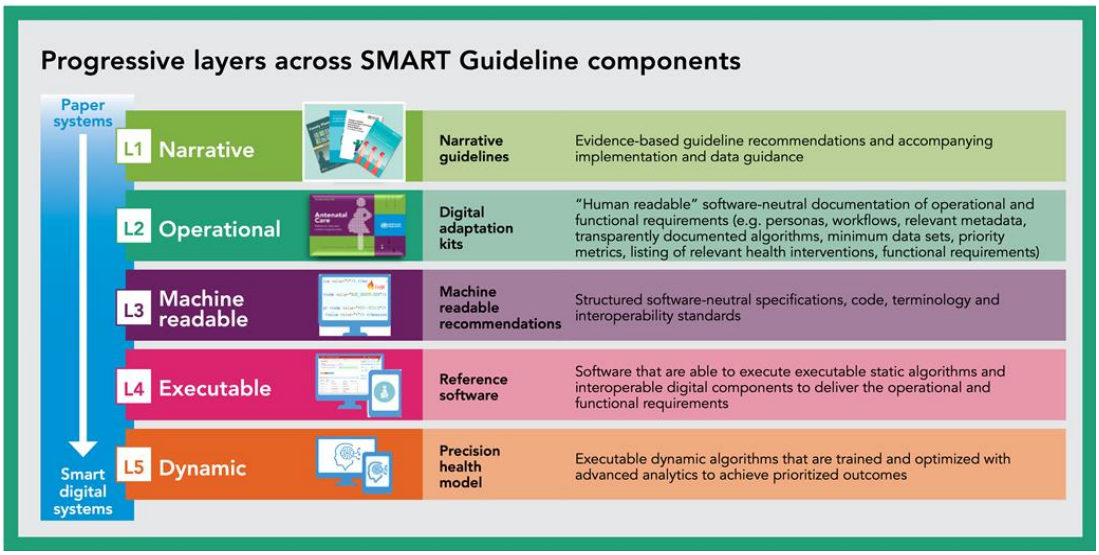

Figure 1. Components *of the SMART Guidelines Source Link[https://cdn.who.int/media/images/default-source/digital-health/image-web-2.png?sfvrsn=2c510fd6_5&Status=Master]*

In this paper, we will discuss the approach that IntelliSOFT Consulting Limited is taking in adopting the DAKs as a way of interpreting client requirements and documenting technical requirements for digital health solutions. We will also address the gaps that are in the current documentation process and how we will assimilate the WHO DAK with IntelliSOFT Consulting Limited's internal processes to achieve optimum results during the project lifecycle.

2 Methods

2.1 SMART Guidelines and DAKs Capacity Building Sessions

The first step in the IntelliSOFT DAK adoption roadmap is internal capacity building sessions aimed at introducing the various project teams to the SMART guidelines with a keen focus on the digital adaptation kits.

The first session was a two-day workshop targeting the Project Management team with diverse roles and expertise within the company. To ensure hands-on experience in utilizing and building DAKs, the workshop combined lectures and practical group sessions where participants developed different DAK artifacts for different assigned projects. As part of the case study, three ongoing projects were selected as case studies for the hands-on group activities that served as examples of the utilization of the DAKs.

The workshop was designed to build capacity within the project management team by: (a) Introducing the DAKs as a component of the WHO SMART guidelines;(b)helping participants understand the key components of DAKs, how they can be applied and what kinds of resources are required to build and apply them;(c)providing participants with hands-on experience for adopting and utilizing a DAK for their respective use cases

2.2 Gaps Identification and DAK customization for various digital health projects.

During the workshop and subsequent discussions, several gaps were identified when comparing the existing SRS documents to the DAK approach. These gaps underscore the need for customization and improvement in our technical documentation practices. Key areas where gaps were identified include:

2.2.1 Clarifying Functional and Non-Functional Requirements:

The SRS documents revealed a need for more clarity in defining both functional and non-functional requirements. This ambiguity often led to confusion and potential issues during development. By embracing the DAK approach, IntelliSOFT aims to bridge this gap by ensuring that functional and non-functional requirements are clearly articulated and comprehensively documented from the project's inception.

2.2.2 Enhancing User Personas and Scenarios:

A significant gap was observed in the level of detail provided for user personas and scenarios in the Software Requirements Specification (SRS) documents. A comprehensive understanding of user needs, backgrounds, and pain points is critical for designing and developing effective digital health solutions. The DAK framework emphasizes conducting thorough evaluations of user personas and scenarios during the project initiation phase. This enables IntelliSOFT to gain deeper insights into client requirements, facilitating the creation of tailored solutions.

It is recognized that customization of the DAK may be necessary for different project streams within ICL, such as Electronic Medical Records (EMRs), Mobile and web applications, and Reporting Systems. Each project type may have unique requirements and considerations, and the DAK approach allows for the flexibility to tailor the documentation process accordingly.

3 Results

3.1 Developing the “ IntelliSOFT Super DAK”

In an effort to streamline and strengthen ICLs internal documentation process, we have created the IntelliSOFT Super DAK which combines the best of the WHO DAK with components of the SRS to create a comprehensive and yet clear document for outlining technical project requirements. The Super DAK has been assimilated into the project cycle. Figure 2 depicts the formation of the IntelliSOFT Super DAK along with the customization for various solutions.

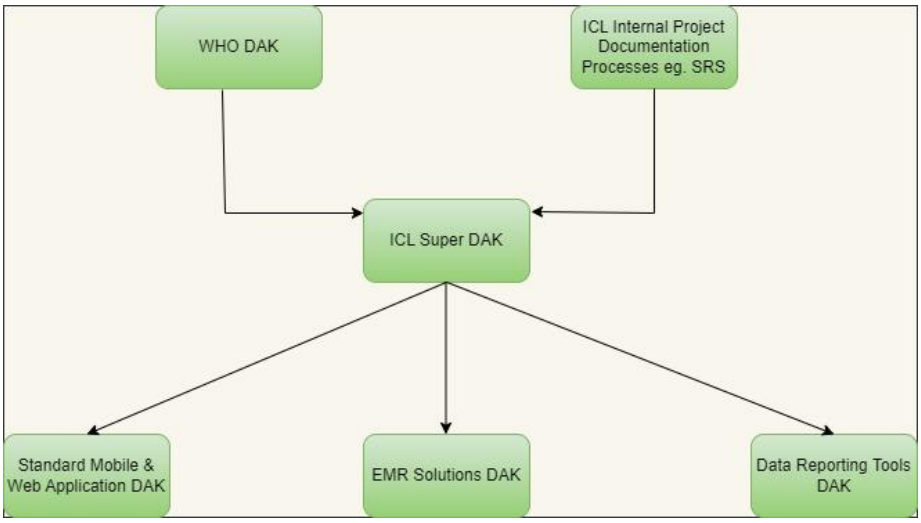

Figure 2. Digital Adaptation Kit Adaptation process to suit the various digital health intervention needs.

4 Discussion

As WHO spearheads the adoption of the SMART guidelines to fast track the development and use of digital health interventions, IntelliSOFT is keen on improving its software development and business analysis process by adopting the SMART guidelines approach which are standards based. IntelliSOFT intends to monitor the impact of adopting the DAKs on the quality and efficiency of the development process which could inform the enhancement of the SMART guidelines approach.

Capacity building is an important step in the inception of any new process to ensure understanding and appreciation of the "why" by the team. The initial workshop held with the project management team at IntelliSOFT helped demystify the WHO SMART guidelines and the potential impact in adopting them. There was great reception from the team who were enthusiastic to lead the implementation of the DAKs in the various projects.

It is clear that the adoption of the digital adaptation kits requires some level of customization to meet an organization's specific needs but offers a robust generic starting point. For IntelliSOFT, the customization includes the addition of some components captured in the SRS like the system architecture. In addition, differentiation of the DAK templates to be used for various solutions like mobile applications for single health programs and complex systems like hospital EMRs is required as one template can not serve all.

I. A Pilot implementation will be adopted where all new projects will use the DAK approach with close monitoring and evaluation of the impact on project-kickoff, product quality and seamlessness in the development process. Findings from the iterative evaluation will be used to improve the process and learnings shared with the SMART guidelines community of practice. Continuous training will be conducted with all project teams as an approach to firm-up the teams capacity in implementing the DAKs.Institutionalization of the DAK approach was identified as a major factor to its success and it was agreed that the DAK development would be factored in a core part of the project right from the bidding stage along with having a dedicated team domiciled within the business analysis docket tasked with overseeing the implementation of the DAK approach in different projects.

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Journal of Health Informatics in Africa

Establishing a Central Data Repository (CDR) for Human Immunodeficiency Viruses (HIV) treatment and follow up data in Ethiopia: Description of the server-side software and infrastructure

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1 Introduction

Several different approaches have been taken to centralising or aggregating data from multiple Health Information Systems (HISs) into a Central Data Repository (CDR) at national or sub-national level in low resource countries. These data sources include point-of-care systems such as Electronic Medical Records (EMR), Laboratory Information Systems (LIS), and Pharmacy Information Systems (PIS). These implementations have demonstrated some of the benefits of centralising and managing data centrally. For example, a CDR system can be used to integrate EMR data and create longitudinal patient records to strengthen patient care coordination and program management. Accuracy, reliability, reduced data redundancy, the need to have reduced consultation of several data sources, cost, real-time access, and reporting are some of the other benefits of centralizing data in one place. This study aimed to investigate several designs and technologies to use in developing the server-side software and the process steps needed to implement the required infrastructure for the central data repository installed at the Addis Ababa City Administration Health Bureau (AACAHB) for HIV data management. The study team considered several technologies commonly used for health data exchange, data pipelines, reporting and visualization [1, 2]. Open-source technologies were preferred in order to establish a solution best suited to meet the need for longitudinal HIV specific programs in a low-income setting such as Ethiopia in a sustainable way. The study focused on server-side systems used to manage the centralised data, including the data pipeline and reporting tooling.

2 Methods

Key stakeholders and decision makers in the health sector from both governmental and private sectors in Ethiopia and other countries were included in Focus Group Discussions (FGD) to document the requirements for data centralisation and integration and implementation discussions. The requirements were then used by a team of software developers to design and develop the CDR solution using existing open-source software solutions using an open architecture and open standards (Figure 1). The software solution and associated reports were implemented in a dedicated data centre at AACAHB with hardware and software security systems and access control procedures. The CDR solution was integrated with existing electronic medical record (EMR) applications implemented at facilities in Addis Ababa. After connecting thirty health facilities, data was collected to ascertain the status of the implementation and the feedback from users and maintainers of the system. Virtual and in-person training was provided to the

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implementation team in Ethiopia. The technical team from Jembi was able to assemble a data centralisation and integration platform using open-source software according to the Open Health Information Exchange (OpenHIE) architecture specification [1] and using the Fast Healthcare Interoperability Resources (FHIRTM) standard (HL7). The CDR receives data from EMR systems through the Open Health Information Mediator (OpenHIM) [2], in the FHIRTM message protocol which is centralized in a FHIR-based Shared Health Record (SHR) repository tool (HAPI-FHIR). An Extract, Transform, Load (ETL) data pipeline then transforms the data into a form suitable for reporting and analytics using the ELK technology stack. This system comprises of Elastic search and Logstash as a database and Kibana as a tool to visualize the data supplemented with Javascript within JSreport to build reports. The system is built with open-source tooling, but is built for extensibility to integrate with other alternatives, such as PowerBI (Microsoft). There is an expected trade-off between the development cost of open-source solutions and the upfront cost of commercial alternatives for business intelligence and data visualization systems. The system was designed with a micro-services architecture allowing for swapping out of components for other technology choices. Jembi experimented with an alternative SQL-based data pipeline and the use of SuperSet for reports and data visualisation and was able to integrate this alternative data pipeline seamlessly due to the architecture. Docker and Docker Swarm are used to package the applications into containers for scalable and high-availability deployments. DevOps tooling was developed into the system technology stack to facilitate support by system administrators. A Kafka message queue component is used to handle data load spikes and the system has undergone stress testing to prove its capability.

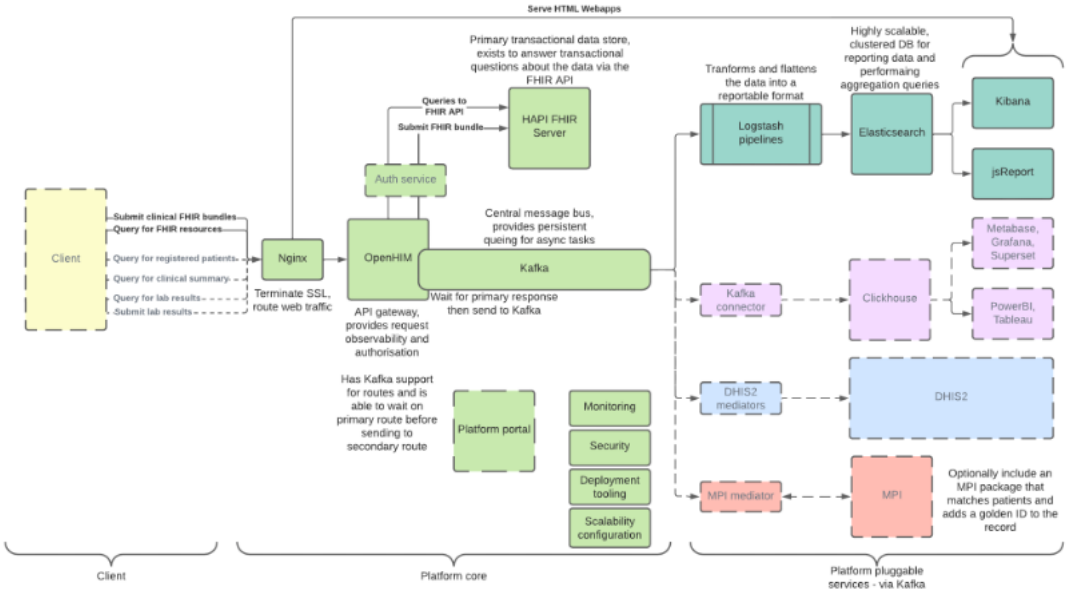


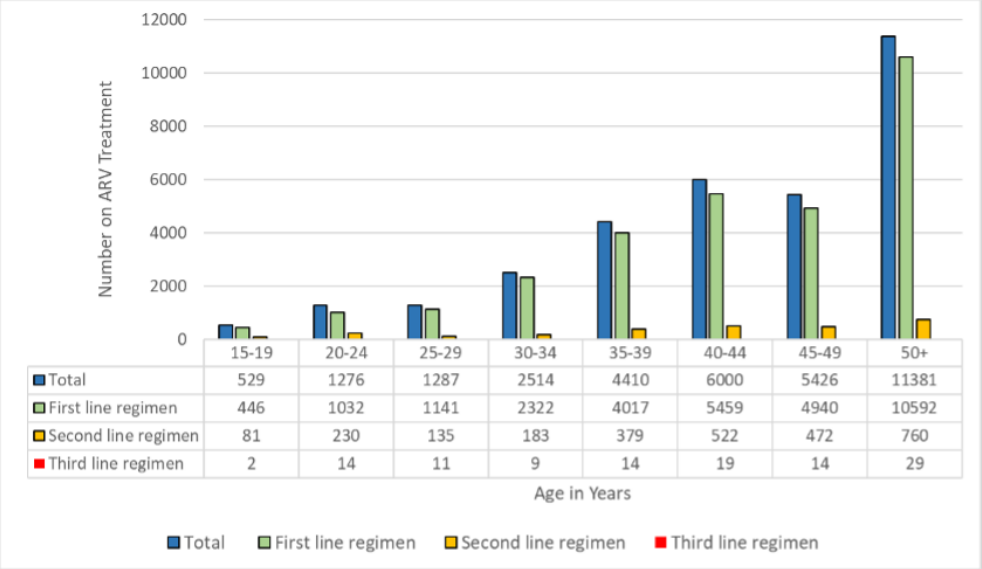
Figure 1. Data Integration and Centralisation Platform

3 Results

The system has been implemented at the AACAHB data center and is presently connected with EMR Systems in thirty health facilities. A trained team at AACAHB is managing the infrastructure, coordination and troubleshooting support as required. The AACAHB team has started generating CDR reports which is shared with relevant teams for evidence-based decision making. The data management and HIV program team are using the CDR report for HIV program monitoring and relevant feedback is provided to health facilities.

Thirty-one health facilities are currently connected with the CDR (5 hospitals and 25 health centers) with a total of 33,155 patient records. We present the regimen level analysis done among adults on ARV treatment in Figure 2. Of the total 32,823 patients on ARV, 91.2% were on first line regimen, 9.2% on

second line regimen and 4.1% on third line regimen. The data at the CDR is analysed for regimen type, interruption in treatment, viral load status and other relevant indicators which is being used for program monitoring and decision making at regional level.



	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50+
Total	529	1276	1287	2514	4410	6000	5426	11381
First line regimen	446	1032	1141	2322	4017	5459	4940	10592
Second line regimen	81	230	135	183	379	522	472	760
Third line regimen	2	14	11	9	14	19	14	29

Figure 2. Distribution of regimen type among adult patients on ARV in 31 health facilities, Addis Ababa, May 2023

4 Discussion

Some initial teething problems have been experienced with the system. For example, one hospital connected to the CDR is working through differences in the number of HIV data elements counted in the CDR versus its own internal system until the CDR system is refreshed. There is also an issue with some of the reports. These are in the process of being addressed. Initial results indicate that the CDR has a number of benefits for AACAHB and potentially for other organizations needing to centralise and integrate EMR data. The open architecture and open standards approach has potential for wider implementation in other low resource environments. In Ethiopia, the CDR system could be used as a foundation for implementing a patient-level data national data repository (NDR), starting with implementing the CDR for other regional health bureau's and then potentially connecting to a national instance. The open-source platform shows potential to be implemented in other low resource countries. An essential requirement for success is transferring skills and building capacity to support the technology and ensure its ongoing implementation success and that implementation challenges are addressed in a timely way. It is also important to work with users to develop reports.

Keywords: Central data repository, CDR, central server, HIV data management, Addis Ababa

Acknowledgements

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Statement on conflicts of interest

None Declared

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Journal of Health Informatics in Africa

Introduction of Barcode labels in the PEPFAR regions of Ghana

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Background and Purpose: Several challenges have been identified as preventing timely testing and reporting of HIV viral load results of patients in the PEPFAR and other regions of Ghana. Among them are bottlenecks created from improper or ineligible handwritten labels of patient specimen numbers on collection tubes. Barcode labels mitigate this challenge for uniform and legible identification and labeling of patient sample tubes.
Methods: Pre-printed barcode labels were distributed to the participating pilot sites. Data Officers and ART Nurses were trained on when to scan and link patients to a unique barcode label number during the regular patient registration process. A WhatsApp platform was created for the participating sites to report any challenges for immediate resolution. Additionally, the sites were required to respond to a questionnaire, sent via Google Docs, to determine the challenges the sites encountered during that week.
Results: After two months of piloting the bar code system at seven ART sites in the PEPFAR regions of Ghana, results indicated that labeling inaccuracies were eliminated, thus improving patient data accuracy compared to practices before the introduction of the bar code labels.

Furthermore, overall turnaround time was improved because bar code label unique identifiers were printed and not handwritten
Conclusions: Introducing the barcode as a patient-unique identifier during registration and as part of the testing protocol improves labeling and patient data quality. Overall turnaround time is improved because results are reported sooner since the laboratory does not have to determine who a particular specimen belongs to before reporting results

Keywords: barcode, identifier, laboratory

1 Introduction

The use of barcode labels has many benefits in the laboratory setting. Barcodes can represent a specimen identifier, patient identifier, or other relevant information and, therefore, can track a specimen from the point of collection to the communication of patient results. It improves data quality by reducing transcription errors, reducing expenditures from improperly performed diagnostic test reruns, and improving patient safety and outcomes. The use of bar code system labeling increases the efficiency of laboratories and simplifies the process of data tracking, both key to the successful performance of any laboratory.

Several challenges have been identified as preventing timely testing and reporting of HIV viral load results of patients in the PEPFAR and other regions of Ghana. Among them are bottlenecks created from improper or ineligible handwritten labels of patient specimen numbers on collection tubes. Barcode labels mitigate this challenge for uniform and legible identification and labeling of patient sample tubes.

Using a specimen bar code label system at the antiretroviral therapy (ART) sites in the three PEPFAR regions of Western, Western North, and Ahafo and the Bono Regional Hospital laboratory testing site will ensure effective workflow, reduce/eliminate transcription errors and improve overall turnaround time for

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patient results. For this effort, the barcode labels were pre-printed by a vendor and distributed to the seven ART sites participating in the pilot.

2 Materials and methods

The Association of Public Health Laboratories (APHL), in collaboration with the National AIDS Control Program (NACP), identified seven high, medium, and low-burden ART sites where HIV patient samples are collected. Six ART sites were provided with handheld barcode label scanners to capture the unique identifier. One ART site, Shama Health Center, manually entered the unique bar code number during patient registration. The Bono Regional Hospital, where HIV viral load testing is performed for these ART sites, was also enrolled in the pilot.

Three indicators were selected:

1. Increased specimen labeling accuracy
2. Patient data accuracy
3. Improved turnaround time

Pre-printed barcode labels were distributed to the participating pilot sites. Data Officers and ART Nurses were trained on when to scan and link patients to a unique barcode label number during the regular patient registration on the electronic patient management system. A WhatsApp platform was created for the participating sites to report any challenges for immediate resolution. Additionally, the sites were required to respond to several questions each week. The questionnaire, sent via Google Docs, sought to determine the challenges the sites encountered during that week.

The pilot sought to explore if the problem of specimen labeling inaccuracy could be mitigated and patient data accuracy improved. Furthermore, the challenge of ineligible handwritten unique identifiers on labels on patient specimens was to be explored.

3 Results

After two months of piloting the bar code system at seven ART sites in the PEPFAR regions of Ghana, results indicated that labeling inaccuracies were eliminated, thus improving patient data accuracy compared to practices before the introduction of the bar code labels.

Furthermore, overall turnaround time was improved because bar code label unique identifiers were printed and not handwritten; this eliminated the challenge of the testing laboratory wasting time to determine the correct sample identification or determine which patient the sample belonged to before reporting it to the ordering clinician.

4 Discussion

Introducing the barcode as a patient-unique identifier during registration and as part of the testing protocol improves labeling and patient data quality. Overall turnaround time is improved because results are reported sooner since the laboratory does not have to determine who a particular specimen belongs to before reporting results. Because a bar code is linked to the patient during registration, the laboratory uses the same unique identifier to report test results.

Journal of Health Informatics in Africa

The use of Electronic Medical Record (EMR) in Ascertaining the Status of Unaccounted Aging-out of Children within the HIV Treatment Cohort in Ethiopia.

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1 Background

In Ethiopia, the cohort of children 0-14 years on antiretroviral therapy (ART) has been declining over the past years despite new enrollments. Some of this decline is attributed to children living with HIV on ART who turn 15 years (age-out). In the past two decades, except on a few occasions when manual registers were used for data collection with already known limitations in updating and reporting, and the Electronic Medical Record (EMR) was not widely available. We present new EMR feature which helped the HIV program in monitoring the exact number of pediatric age-out at service delivery level.

2 Methods

Pediatric age-out was considered as a major need in the EMR requirement. EMR enhancement and expansion has been a priority in the past five years: expanded from 111 health facilities (HF) in 2018 to 715 in 2022. The pediatrics age-out feature was embedded in the EMR based on the program requirement. The EMR can generate the number and line-list of children who age-out in each reporting period. The EMR is deployed in 715 HFs, and we present the result in eleven high HIV case load HFs in Addis Ababa managing more than 500 children on ART and implementing the EMR-ART version 6.0 for at least one year. To account for the number of pediatric age-out, data was collected from the EMR-ART system using a script written specifically for this purpose and a pretested checklist. We reviewed pediatric cohort data from December 31, 2022 from 11 facilities and compared it with the baseline data of December 30, 2011G.C collected from the same sites. The data was entered in to MS-excel spreadsheet and analyzed to describe the clients aggregate figure for treatment current including for <15 years with potential increasing and decreasing factors for the reporting months chosen to explain the treatment current trend and proportions of pediatric aged-out.

3 Results

Starting from December 30, 2011, a total of 5697 children under 15 years of age were active on ART. By December 31, 2022, 2915/ 5697 (51.2%) children were active on ART. Based on the age-out line-list feature of the EMR, 2121/ 2915 (72.8%) active children on treatment were age-out to adult cohort which is so huge proportion that could not be easily defined without the EMR function. Clinicians and HIV program team are now using the age-out results on a quarterly basis.

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4 Conclusions

The EMR pediatric age-out feature is currently available at HF level and could be integrated into the central data repository at national and sub-national levels to facilitate better decision making at higher levels. The EMR system addressed the critical gap in HIV program data by defining pediatric age-out which is now being used more frequently for patient accounting, planning and enhanced quality of care. HIV treatment related EMR systems could include age- out as a major requirement.

Keywords: Electronic Medical Record, EMR, HIV Program Improvement, Data Use, Ethiopia

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Journal of Health Informatics in Africa

When Hiding in Plain Sight Matters: A Case Study on the Application of Geoprivacy for Public Health using Jupyter Notebook

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Keywords: geoprivacy, Jupyter Notebook, Python, privacy, geo-referenced data, spatial and temporal aggregation, noise injection, differential privacy.

1 Introduction

There is need within global health programs to provide high-precision geographic maps of disease cases within localized populations-at-risk while simultaneously protecting individual privacy and confidentiality. Maps must maximize benefits while eliminating privacy concerns and potential misuse or unintended consequences to populations that are often stigmatized, persecuted, and at-risk for personal harms. Geoprivacy strikes a pragmatic balance between the need for precision public health analyses of populations at-risk and the security, privacy, and anonymity of individuals within those same populations.

2 Methods

The authors used a case study approach: (1) To apply geoprivacy methods to the 1854 London Cholera outbreak data (by Dr. John Snow), specifically hexagonal binning (spatial aggregation, Figure 1) and donut geomasking (noise injection, Figure 2); and (2) an audience interaction approach to apply concepts learned using a hypothetical scenario. The authors walked the participants through the case study as well as the steps to achieve donut geomasking and hexagonal binning using computational narratives within Jupyter Notebook

Figure 1. Spatial Aggregation using Hexagonal Binning

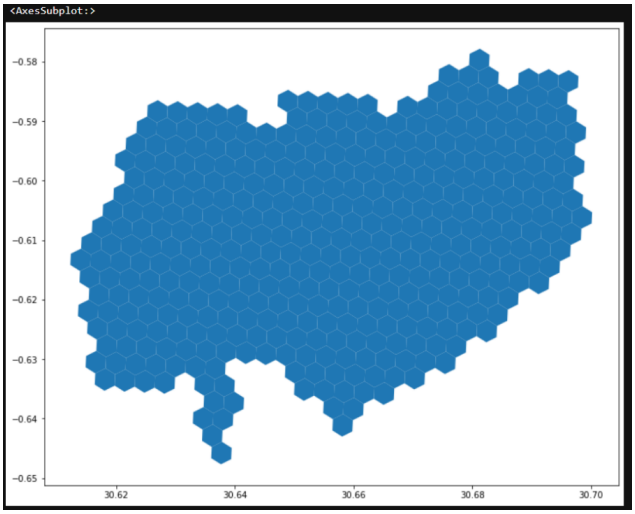

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Figure 2. Noise introduction with Donut-Geomasking

3 Results

The authors demonstrated the utility of geoprivacy approaches to perturb and aggregate coordinates using donut geomasking and hexagonal binning respectively, within interactive computational narratives in Jupyter Notebooks. Donut-geomasking utilizes an approach that essentially takes the original coordinate point and draws a virtual donut (with inner and outer diameter) about the origin point. Donut-geomasking then seeks to "perturb" the original coordinate by moving it between the inner and outer diameter of the virtual donut at a random bearing point. This allows a randomized direction of the perturbation and a minimum displacement distance (inner diameter radius) and maximum displacement distance (outer diameter radius). In this manner, donut geomasking displace the original point at a random bearing and distance that protects the original household or point from potential reidentification and disclosure risk. A second method, hexagonal binning, is a type of areal aggregation that eliminates the specific coordinate point by aggregating to a hexagon that has a certain radius similar to a circle – but with a resolution large enough to encapsulate several hundred building footprints and reduce or eliminate potential reidentification of the original household coordinates by areal aggregation within a proximate vicinity of the original coordinate.

4 Discussion and Conclusion

The availability of geo-referenced data offers both opportunities as well as threats to global health programs both seeking to provide high-precision public health response to epidemics while at the same time protecting the privacy, confidentiality, and security of individual health data. The use of high-precision geo-referenced data raises concerns about the potential for disclosure of sensitive information about individuals and communities. There is a need for simple, easy-to-use geoprivacy methods to enable global health to leverage these geospatial data to maximize benefits while eliminating any potential risks to individuals and communities. This paper presents geoprivacy methods to protect location privacy using interactive computational narratives in Jupyter Notebook

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Journal of Health Informatics in Africa

Need Assessment for Using an Automated Mobile Based Application to Prevent Neck and Lower Back Pain Among Office Worker (Computer Users) in Nyarugenge And Kicukiro Districts

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The investigated the need assessment for using an Automated mobile based application to prevent neck and lower back pain among office worker (Computer Users) in Nyarugenge and Kicukiro Districts. The study aims to explore the challenges that might be met in using an automated mobile based application intervention among office workers in preventing postural neck and lower back pain and assess the requirement needed to design an automated health lifestyle coaching system in office workers in order to prevent postural neck and lower back pain. The study was based on qualitative methodology using a structured interview to collect data from the respondents using purposive sampling techniques. The study found that the app would be very useful to manage back pain and lower back pain among office worker. The study recommends that adoption and implementation of digital health innovations by Ministry of Labor in Rwanda, the administrative staff in Nyarugenge and Kicukiro district should take measures by participating in physical activities at the workplaces and working hours should be reduced and regulated by the Rwandan Government.

Keywords: need assessment, an automated mobile based application, neck pain, lower back pain, nyarugenge, kicukiro districts, Rwanda, health informatics

1 Background

According to Bryndal, Glowinski & Grochulska (2022), neck pain (NP) and low back pain (LBP) are commonly spinal pain among computer users, one of the major causes of disability globally, and also are common in sedentary office workers. One-year prevalence rates for neck and low back pain among office workers have been shown to range from 42% to 69% and 31% to 51% respectively although improvement of neck and low back symptoms can occur. However, Akkarakittichoke, Jensen, Newman & Waongenngarm (2022), opined that daily activities can lead to painful back problems or back disorders are commonly because of work-related awkward postures. It results in sick leave, disability, producing significant restrictions on usual activity and participation among many office workers. (Workneh, 2020).

The lower back is where most back pain occurs. It includes the five vertebrae (referred to as L1-L5) in the lumbar region, which supports much of the weight of the upper body. The spaces between the vertebrae are maintained by round, rubbery pads called intervertebral discs that act like shock absorbers throughout the spinal column to cushion the bones as the body moves. Ligaments hold the vertebrae in place, and tendons attach the muscles to the spinal column. Non- specific NP and LBP are now clearly recognized as a major public health problem. (Almeida & Kraychete 2017). A study conducted in Poland by Malińska, Bugajska & Bartuzi (2021) showed that over 48% of respondents from office workers complained of MSDs experienced neck pain and lower back pain due to long hours spent working with a computer sometimes

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with poor posture, no work time break and job demand. Acute neck and lower back pain are classified as back pain lasting's a few days to a few weeks while sub-acute back pain lasting's 4 to 12 weeks and chronic back pain lasting's longer than 12 weeks. (Demissie et al. 2021).

Neck and lower back pain among office workers including bankers leads to a negative economic impact with increased absence from work and lost productivity. It is causing global implications to various sectors like economical, societal, and public health. The lifetime incidence of LBP was 58–84% globally which affects as much as 80% of people in developed countries, while the most frequent areas of complaints were neck 61.6% and 49.3%lower back. Moreover, 17% and 27% of office workers who report a new onset of neck and low back pain report that these pain problems become chronic, respectively. (Jegnie, 2021). A study conducted in Rwanda by Kanyenyeri, Asiimwe, Mochama & Nyiligira (2017) showed that the prevalence of back pain among the bank staff was 45.8% caused by various physical demands and prolonged sitting or standing postures. In addition, the nature of office work and the office environment has been associated with increased risks of NP and LBP due to the sedentary working style and the alignment of their chairs, table, and computers not ergonomically well designed.

2 Problem Statement

Neck and lower back pain affect many individuals and have an effect on well-being especially people working with computers in their working places. Neck and lower back pain is regarded as common reason for work absenteeism, lost productivity and care-seeking. This statement is in line with the study of Williamson & Cameron (2021), who found that most people 85-95% who seeking healthcare provider with neck and lower back pain do not have a specific identifiable origin for their pain. Other studies explain that office workers involved in prolonged sitting during their work shift were more likely to report NP and LBP. The overall increase in the burden of NP and LBP is likely to be driven by ageing and an increasing population, however there may be other contributing factors. According to Dutmer et al (2019), over 80% of the total costs attributable to NP and LBP are due to indirect costs such as loss of productivity and disability payments in countries that have functioning social welfare systems while worldwide, back pain is costly health problem. As Neck and lower back pain are a big common problem worldwide, many solutions were still proposed in order to reduce the future increase in number of back pain mostly neck and lower back such as active break and posture shift position.

3 Objectives of the Study

- To explore the challenges encounter in using an automated mobile based application among office workers in preventing neck and lower back pain;
- To assess the requirement needed to design an automated health lifestyle coaching system in office workers in order to prevent postural neck and lower back pain;

4 Literature Review

4.1 Challenges encounter in using an automated mobile based application intervention

A study conducted in Nepal, shown that the biggest issue was the absence of suitable technical resources such as electricity and the internet, as well their lack a motivation from governance to their staff in order work their lack supportive policies. Parajuli, Bohara, Shanmuganathan, Mistry & Yadav (2022), different study found that Health Information Systems (HIS) was ranked as the first factor among other factors followed by a lack of digital knowledge cause not being able to evaluate and integrate digital information Effectively. Unreliability of available data, the heterogeneous nature of data sources and large volumes of data including epidemiologic, surveillance, and health services data required for public health services gathered across various health systems without broad standards for reporting and consistency was emphasized as a problem of data reliability. Further, data quality issues, including incomplete data, were said to be a challenge

According Naslund JA, Aschbrenner (2019), more robust computing infrastructure including high-bandwidth, low-latency computer networks and clusters of machines for computation are required to take advantage of Further, in resource-limited settings, unreliable power supply is a complicating factor. In addition to providers, public health service users also require access to computers, smartphones, and Internet services, which are often disparately distributed along socioeconomic gradients. These infrastructure requirements are closely related to funding and human resource needs, as the development of infrastructure needed to implement effective information systems has been slow, especially in financially limited local health departments.

According to Chowkwanyun (2019), other challenges include disparities in the impact of overlooked potential consequences of digital technologies, such as data privacy breaches, data misuse, and biased algorithms leading to the perpetuation of stigma on marginalized populations. Widespread lack of digital health equity implementation frameworks and rigorous evaluation of the equity impacts of these digital technologies may further complicate equity challenges. Furthermore, given that the ability to verify the information is dependent on digital health literacy, information overload on the general public and the burden of health-information verification responsibilities placed on individuals were said to have the potential to worsen already-existing health disparities.

4.2 The requirement needed to design an automated health lifestyle coaching system in office workers in order to prevent postural neck and lower back pain.

Digital therapeutic care apps are innovative new treatment programs with a variety of indication-specific video-based exercises and educational material accessible through a smartphone or a web-based app in addition to that it has a long term effect on quality of life. Digital health technologies (DHTs) comprise a wide range of products including apps, software and online platforms that are intended to benefit people or the wider health and care system. In view of the above, Salinas-bueno (2021), suggested that computer users must pay attention on the following tips:

- **View your computer screen with a straight neck,** put your screen in front of you at a comfortable viewing height.
- **Put your screen sideways to a bright window,** to minimize the chances of visual eye strain from glare or partial retinal adaptation.
- **View any paper documents with a straight neck,** Don't read from an iPad or papers that are flat on your table or your head will constantly have to move up and down.
- **Put your keyboard and mouse or touchpad at a comfortable height in front of you.**
- **Don't use a soft, squishy wrist rest,** it may seem like it's providing support, but putting anything beneath your wrists adds compression on the finger flexor tendons and on the median nerve.
- **Alternate between typing/mousing and using voice input**, Voice recognition is good for most text and emails.
- **When sitting, rest your feet flat on either the floor or a foot support,** if your feet don't reach the floor, use a box, pile of books, cushion or footrest.
- **Limit the time you work on your bed,** a bed is even worse for you than a chair, because unless you sit on the side of the bed, your legs was crossed or extended horizontally, acting as support for your laptop.
- **Avoid prolonged standing or sitting for computer work.** The existence of standing desks makes many people believe standing is a better option for their bodies.

5 Methodology

Cross- sectional design was used to the employee who worked at least six months. for data collection over a single time period. This study was conducted at Nyarugenge and Kicukiro districts which are 2 of 3 districts comprising Kigali city. The study population included all public servants who are working at targeted institutions at the two cities. Purposive sampling was used in selecting the respondents. Data was collected in 6 days at selected areas during working hours for the participants to be available. Interview guides with general broad questions was used. Thematic analysis using codes were used for the analysis.

6 Results and Discussion

6.1 Theme one: demographic variable

The study reveals that more than half of the respondents are male, and have of them their age fall between 36-43 years. Majority work with computer for office based works and they prefer to use phones than computers and they engage in sport to reduce back pain.

6.2 Theme Two: Health Promotion

" (P4). This was expressed in the following speech marks, ‘’well, of course, when people are healthy, the company benefits because of reduced doctor visits, absenteeism, increased productivity and increased overall employee life expectancy and more" (P2 &P12). However, mental health wellbeing

6.3 Theme Three: Using an Automated Mobile Based Application

This was elicited from the following quotes: "therefore, in general, the institution uses people who are healthy, you can work five days and two days, but you would work two days out of two, for example, I gave the institution, so it would be beneficial because every organ damages the body and becomes unstable, if the body is disturbed and production is low. It would benefit the institution because at least the employees have a healthy life, good health through this system will help office workers to refresh their mind, relaxing. When you think well, when you have concentration, you work well and the results are good" (P7&P11)

All participants perceive that using an automated mobile based application to prevent postural neck and lower back pain. The following expressions were elicited from the participants:

"…I think this application would be very useful, first of all, the worker would have a healthy, good life. We have had experience with the workers here, we have been talking to them, they suffer from back pain and there are those who have to go to surgery, they have to undergo surgery on part of their neck, back, and what seems to be caused by sitting for a long time, going to the computer for a long time, going to the telephone for a long time, etc." (P5).

"It is very important to help us, it is often because the computer is life at work and it is the tool that you have to live all hours until you leave work in the evening, often when you do it for a month you feel tired, which can also lead to other diseases." (P6).

"as employees who always use computers or machines, it is difficult for a person to give a plan to go and rest aaah in the specified hours or maybe he will give you that plan because especially in the head, there is a lot of work" (P6, P9)

6.4 Theme Four: Emergencies

This was expressed in the following quotes: "Sometimes the meetings are urgent and they get priority over the sport, there is the citizen who has urgent case and say whatever what the problem was solved when I get to the one who receives me" (P7&P11)

6.5 Theme Five: Internet Usage

This was highlighted by the following responses: ‘’if we would like to know how it works if it doesn't require internet, then we would ask how much internet it uses to connect, is it only on the machine or on the phone? It's a real telephone, we should first check if it doesn't look like data, maybe, so that the employee whenever he doesn't have data or his connection can open it, then we will see how long it will take to open it…." (P1)

6.6 Theme Six: Personal Factors

The participants expressed as follows: “have you thought about people who don't have smart phones or computers? I understand that there is a way to work with MTN, TIGO, ITEL and other communication systems so that even a person with a small phone can see the notification. Because everyone does not have the same skills or know how to do different exercises’’ (P2). “in the beginning, something must first be like a habit, and it may not be understood, but as the days go by, things can be understood because once people have done it, they cannot immediately do it because we have sports hours, some of us they go to the gym, other they don't have time to go to the gym due to they have different errands like wedding, family issues, birthdays and other things and sport is also life” (P3)

7 Recommendations

The recommendations in this study are given based on the results:

Adoption and implementation of digital health innovations by Ministry of Labor in Rwanda
The administrative staff in Nyarugenge and Kicukiro district should take measures by participating in physical activities at the workplaces.
Working hours should be reduced and regulated by the Rwandan Government

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A comparative review of the Logical Observation Identifiers, Names and Codes (LOINC) and the National Reference Price List (NRPL) to encode the WHO List of Essential In Vitro Diagnostics (WHO-LEVD).

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The World Health Organization (WHO) List of Essential In Vitro Diagnostics (WHO-LEVD) [1] proposes a list of pathology tests to be available under universal health coverage and provides internationally appropriate textual descriptors of these In Vitro Diagnostic (IVD) tests. However, for the WHO-LEVD to be fully utilised in clinical practice and research, each IVD must be coded by a standardised, internationally recognised, and maintained coding system. South Africa uses the National Reference Price List (NRPL) for coding pathology tests.

This review compared the NRPL and Logical Observation Identifiers, Names and Codes (LOINC) [2] coding systems and mapped these to the WHO-LEVD.

The NRPL does not capture data critical for research and national planning data, nor is the NRPL suitably updated. The factors considered in implementing a pathology coding system are many and should include 1) appropriate data for clinical investigation for reporting clinical and research purposes, 2) The coding should be internationally recognised, 3) the coding should be free to use and 4) must be competently updated regularly. This comparative study found that LOINC was superior to the NRPL regarding these essential factors. This supports the further investigation of LOINC as the pathology coding system to be used in South Africa to achieve the goals set for universal health coverage.

1 Introduction

1.1 The WHO Model List of Essential In Vitro Diagnostics (WHO-LEVD)

The WHO-LEVD provides a list of in vitro diagnostics that should be included in a national essential pathology diagnostics test list [1].

The WHO-LEVD consists of 140 entries covering general tests for routine patient care, specific diseases, and blood screening covering 27 of the top 30 (by frequency of use) pathology tests in South Africa [3]. Of the 140 entries, 14 are generally termed 'panels' such as 'Lipid Profile'. Where possible, these panels have been expanded to their constituent diagnostic tests. Further, some diagnostic tests appear under more than one section. In this review, we have identified 125 unique individual diagnostic tests and 14 panels, which we have used for comparison.

The WHO-LEVD provides information for each test, including the intended purpose of the diagnostic test, assay technique, specimen types, pathology discipline generally associated with the test and diseases and conditions which may be related to the test.

This information is presented in a textual, tabular format only and does not employ any form of coding to define each IVD. This allows WHO member countries to adopt the coding system appropriate to their needs.

There is currently no WHO-approved coding system for pathology tests.

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1.2 The Need for and the Characteristics of an Appropriate IVD Coding System

An appropriate coding system is required to utilise the WHO-LEVD for clinical, research, costing, and tariff purposes.

A coding system must accurately identify the test and its pertinent attributes to ensure the correct interpretation of results, inform clinical decisions, interpret research data and provide a system that can communicate costs and charges and be useable for procurement and stock management.

McKnight et al. (2019) [4] suggest using LOINC as a coding system to develop and use the WHO-LEVD. Features of LOINC cited by McKnight et al. (2019) that apply to the South African context include:

- Measurement of research utilisation and accurate cost comparisons
- Reduction in ambiguity facilitates reduced clinical requests and reporting errors. 70% of pathology test errors occur before the analytical phase. Errors include wrong test choice and incorrect sampling [5]. Unambiguous and sound coding systems must be used to identify process errors outside of the laboratory measurement phase itself.
- LOINC coding facilitates accurate inter-laboratory communication and accurate communication with health care providers. Appropriate coding ensures test identification and integrity of results communicated between various role-players in the healthcare delivery and research sectors across local and international platforms.
- Appropriate coding improves the stock and quality control of diagnostic kits, equipment and reagents and facilitates identification and planning for the range of diagnostic services offered to patients.

Further to the criteria raised by McNight et al. (2019), an IVD coding system should describe the following axes as a minimum [6]:

Analyte:	Constituent, e.g., Creatinine, Sodium, Lymphocytes
Specimen:	Sample, e.g., CSF, Urine, Plasma
Measure:	Amount of Analyte, e.g., Volume, Concentration
Units:	Measure, e.g., mmol/l, mg/ml
Method	Assay Technique, e.g., Spectroscopy, immuno-assay
Time	Interval of test, e.g., point in time, 24-hour collection.

1.3 Current Pathology Coding in South Africa - The National Reference Price List (NRPL)

South Africa uses a text-defined National Reference Price List (NRPL) system for pathology coding. However, this system was developed primarily as a billing or tariff system and is indeed a “Price List” rather than a coding system.

1.4 Shortcomings in the NHRPL

The NHRPL has many shortcomings, including a lack of updates, absence of specimen description, poorly defined panels and omission of analytes and analyte specificity.

Maintenance

The last published update of the NRPL took place in October 2008[7]. As a result, there have been no additions of new codes for new analytes or new techniques of analysis. Similarly, there have been no updates to the RVUs (Relative Value Units) or reimbursement values.

As a result of these fatal flaws, there has been a proliferation of ‘user-defined’ codes agreed to by funders and providers outside of a nationally regulated process. Furthermore, providers and

funders have introduced their own 'supplementary' data requirements to make the NRPL function as a pathology tariff system.

Inclusion or absence of specimen information

An NRPL code may describe the specimen and the analyte, e.g., plasma sodium is assigned the tariff 4114, whereas urinary sodium is 4316, and 4416 applies to CSF sodium. However, there is no code for pleural fluid sodium as an example. In such cases, the code most similar in cost is used for the non-existent code. Subsequent mining of this data will produce meaningless, and indeed probably dangerous, outcomes.

A code may include a measurement technique, e.g. Blood (or plasma) Calcium as measured by spectrophotometry (code 4017) and measured by Ion Selective Electrode (ISE) (code 4106). This reflects the different costs of each methodology. However, even at the tariff level for urine samples, code 4025 is available for spectrophotometry, but there is no code for calcium measurement in urine by ISE.

Panel Tests

A single code can describe a 'panel' of tests, for example ", Electrolytes & Urea" (tariff code 4171) or "Blood Gases" (4076). This leaves the path open to interpretation regarding which analytes are included in the test panel. Further confusion is created in the latter case where, if each constituent analyte is measured, then each different analyte is coded 4121. Whilst this may or may not satisfy the billing requirements for the tests, it is fatally flawed in determining which test was done. Again, the data has no value for clinical research and other crucial, necessary research such as national planning.

Omission of Analytes and Analyte Specificity

A code (4172) describes a technique, EMIT (Enzyme Multiplied Immunoassay Technique), without any reference to the investigated analyte. Immunoassay techniques are commonly used to measure drugs, whereas the code used does not include what drug is being identified and measured. This coding approach reflects another fatal shortcoming in the NRPL system as an appropriate pathology coding system.

Code 3974 defines Polymerase Chain Reaction (PCR). The applications of this technique pertain to many analytes. Thus, the test to detect HIV, Clostridium, Herpes Simplex, Human Papilloma Virus, and SARS-CoV-2, all have the same code, 3974, when measured using the PCR technique.

1.5 Logical Observation Identifiers, Names and Codes (LOINC)

The development of LOINC was initiated in 1994 by the Regenstrief Institute research scientists, who continue to develop it with the collaboration of the LOINC committee [8].

LOINC codes comprise a set of universal codes and descriptors to identify laboratory and other clinical observations. This facilitates the exchange and e-storing of results for clinical measures, outcomes management and research. In addition, this offers the ability to identify observations in electronic messages such as Health Level Seven (HL7) to allow healthcare providers, public health departments and other appropriate healthcare stakeholders to store and use results appropriately.
Using LOINC promotes the implementation of standardised diagnostic tests and procedure terminologies to support the safe, accurate and effective exchange of health observation information. With the appropriate and managed implementation, there will be one specific LOINC code for the same specific assay performed in any laboratory in any country that has adopted the system.

1.6 The Structure of LOINC

LOINC codes consist of axes:

Component	- What is the test looking for? (analyte, e.g., Glucose)
Scale	- What format are the results (quantitative, ordinal, e.g., mmol/l)
Property	- What is being measured (mass, ratio, volume, etc.)
Timing	- What time frame is being covered (point in time, 24 hours, etc.)
System	- What type of specimen (serum, whole blood, urine, etc.)
Method	- What method was used (atomic absorption, chromatography, etc.)

Each LOINC code is assigned a unique numeric code (with an additional check digit), a long name, a short name and optional additional attribute information or classes.

2 Methodology

Mappings were based on the following criteria: -

Test description:	Sodium, Glucose, etc.
Technique (Method):	Dipstick, Analyzer, etc.
Sample Type:	Blood, Urine, etc.
Measurement Type:	Concentration, Presence, Ordinal, etc.

Mapping to NRPL was performed manually using an electronic copy of the NRPL code set. The primary search to identify an appropriate code was by using the test description. If located this was further refined by considering the technique, sample type and measurement type. Where a direct match using the test description was impossible the test technique was considered as a possible partial match. In the NRPL system frequently the test technique has a code, but there are no specific codes for each of the tests to which it can be applied, for example, PCR technique, NRPL code 3974. This technique, and therefore code, can be used for detecting of a wide range of pathogens. Identifying any specific pathogen using this technique, for example SARS-CoV-2, which would usually be considered a diagnostic test, does not have its own unique NRPL code.

Mapping to LOINC was accomplished using the Regenstrief Institute RELMA tool [9] with additional confirmatory online LOINC search engines [10][11]. The RELMA tool is a search engine downloadable from the Regenstrief Institute. On entering a test description, the tool offers a list of potential matches, including additional information relating to the investigation such as the possible techniques, sample type, etc. The LOINC coding system typically provides more detailed information of the parameters surrounding the diagnostic test than is provided for in the WHO-LEVD. More than one LOINC code could frequently apply to a single WHO-LEVD diagnostic test.

3 Results

With Panels unbundled, 125 individual IVDs were extracted from the WHO-LEVD and used in the mapping exercise. All individual investigations could be successfully mapped to one or more LOINC codes. The NRPL coding system catered for 65% of the IVD investigations to a level reflecting the detail given in the LEVD. Table 1 provides a summary of the mapped IVDs.

Table 1 : Summary of IVD's Mapping to NRPL and LOINC by Discipline

Discipline	No. Of WHO IVD's	Fully Mapped To NRPL	Partially Mapped To NRPL	Fully Mapped To LOINC
Blood Transfusion	2	2	0	2
Clinical Chemistry	46	40	6	46
Haematology	17	16	1	17
Histopathology	6	1	5	6
Microbiology / Virology	11	4	7	11
Serology	43	18	25	43
Total	**125**	**81**	**44**	**125**

Seventy-eight of the IVDs contained no specific assay format information in the LEVD nor the NRPL description. Therefore, these situations were treated as a match on the assay format for this exercise.

The primary reasons for the partial mappings to NRPL are listed in Table 2.

Table 2 : Reasons for Partial Mapping of IVDs to NRPL by Discipline

Discipline	Partially Mapped To NRPL	No Match on Assay (IVD)	No Match on Assay Format	No Match on Sample
Blood Transfusion	0	0	0	0
Clinical Chemistry	6	5	0	1
Haematology	1	1	0	0
Histopathology	5	5	0	0
Microbiology / Virology	7	7	0	0
Serology	25	25	2	1
Total	**44**	**43**	**2**	**2**

3.1 Challenges Identified During the Mapping

WHO-LEVD

In some instances, a panel was listed in the WHO-LEVD, but the specific tests anticipated to be included in the panel were not detailed, for example, the diagnostic test 'Urine Chemistry' (page 23 of the WHO-LEVD). This states the purpose as "To detect and quantify substances in the urine associated with metabolic disorders, renal dysfunction or urinary tract infections" but does not state what these 'substances' should be. It is suggested that the constituent analytes must be specified to ensure completeness and standardisation across stakeholders.

NRPL

Further to the limitations inherent in the NRPL coding system referred to above, a further inadequacy of the NRPL became apparent.

The WHO-LEVD lists several constituents whose presence in urine should be detected via urine dipstick analysis. The NRPL code 4188 for urine dipstick is a single code that identifies a urine dipstick analysis with any number of undefined tests or constituents available on the test strip. Therefore, the WHO-LEVD urine constituents could be mapped to the NRPL code of 4188. However, there is no indication that the constituent required would be on the strip used (based on its NRPL code) and no way of communicating the specific analytes tested for.

LOINC

In the case of specific laboratory investigations, LOINC provided for both actual concentration (mmol/l, etc.) as well as ordered (ordinal) result types (1+, 2+, 3+, etc.), each having their respective code applicable to each scale. However, in the LEVD, there are listed investigations that do not state the scale proposed, e.g., Urine Bilirubin, which cannot be accurately mapped to a single LOINC code.

Within the LEDV, tests may have their assay method set at the least technically sophisticated, e.g., dipstick for glucose. However, the lab may run the assay at a more advanced technical level. Therefore, other qualifying LOINC codes need to be considered.

Some tests do not, and cannot, have a single LOINC code. LOINC provides more than one possible code for many constituents, depending on the 'Method' used in the assay. However, there is also commonly a LOINC code called 'Method' independent, i.e., no method is specified. In the case of Lactate dehydrogenase (LDH) one of the enzymes listed in the LEVD, no LOINC code is available for all methods (no method specified). This is because two primary method principles are involved in measuring LDH, Pyruvate to Lactate and Lactate to Pyruvate. These two principles generate different ranges of results when performed on the same sample. They, therefore, would pose significant clinical risk within the result messaging environment should the method not be indicated (via LOINC code) to ensure appropriate result comparisons and interpretation.

4 Summary and Conclusion

Pathology diagnostics in South Africa is highly digitalised. Almost every laboratory (public and private) is fully computerised. Consequently, the use of coding *per se* is ubiquitous. An urgent need, however, exists for a single pathology coding system to be regulated for use across all laboratories in South Africa. Such a system must comply with the requirements for a pathology coding system referred to earlier.

A pathology testing coding system must accurately identify the list of essential investigations (in the LEVD) and accommodate laboratory, clinician, and researcher needs.

NRPL codes did not fulfil the above requirements.

LOINC codes accurately and comprehensively describe every WHO-LEVD investigation. In a number of cases, there is a one-to-many mapping of WHO IVD to LOINC codes due to the greater granularity of LOINC compared to the LEVD description. However, this granularity provides additional valuable information on the test being coded.

LOINC appears to satisfy the requirements of implementing the WHO-LEVD and providing the diagnostic pathology laboratories with a coding system to replace the flawed NRPL coding system.

The adoption of LOINC as a national standard, as considered in the "South African National Health Normative Standards Framework for Interoperability in e-Health" [12] (HNSF), would contribute substantially to the implementation of an Electronic Health Record (EHR) as envisaged for the NHI. It would also facilitate the development of an interoperable database as with other appropriate coding systems for diagnosis, intervention, function, pharmaceuticals, etc., allowing the country to create the necessary systems for clinical use further appropriate clinical research.

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Journal of Health Informatics in Africa

Implementing Interoperability Layer to Support Health Information Exchange in Tanzania

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Sosthenes Bagumhe is a human-centered design expert with over 13 years' experience in Information Systems project management and implementation. Working with Ministry of Health, he has contributed to developing and deploying state-of-the-art ICT systems at national levels. Currently Sosthenes is leading the implementation of Health Information Mediator as component of Tanzania HIE, which has integrated nine legacy systems including DHIS2, LMIS, Health Facility Registry, National, Referral and Specialized Hospital's Systems

Abstract. In the health sector, achieving Sustainable Development Goals (SDGs), universal health care, improving accountability and improving health outcome are all dependent on improved decision making and a harmonized national information system across health and related sectors. A National Health Information Systems Architecture is essential to identify data needs and interoperability between multiple systems to make efficient use of resources. Implementation of Health Information Exchange through health information Mediator is one such approach. The Ministry of Health, Tanzania has made some progress in leveraging ICT to improve some key aspects of the health system; however the current ICT initiatives and innovations has been driven by needs within a particular domain of the health system, making it difficult to address crosscutting needs. Thus the Ministry of Health, Tanzania formulated its health information system application architecture and prioritized a need for interoperable health information system to improve provision of integrated care across the continuum of service delivery based on enterprise architecture. Interoperability between various health information systems intends to increase ability to triangulate and compare data across domains/tiers/functions and resources; increase citizen access to health information; better continuity of care across program / facilities/ health needs; and, improved data quality by reduced manual data entry / transfer and thus enhance the premise of collecting data once and use multiple times. We will share our experiences from an ongoing effort to implement Tanzania Health Information Exchange (HIE) using Interoperability Layer to help the health system in Tanzania identify and fulfill data needs from multiple sources to support decision-making at multiple levels of health system. Specifically, we will share the experience of how Tanzania has managed to implement Heath Information Mediator for information exchange between Different health domain such as HFR, electronic Human Resource System, eLMIS, DHIS2, VIMS, Epicor and so; the role of standards in achieving interoperability across multiple healthcare systems and domains; the use of user-centered design with consideration for user needs and other preferences; and the need for ongoing capacity building to improve and sustain systems.

Keywords: Interoperability, Health Information Exchange, Health Information Systems Architecture, eLMIS, DHIS2

1 INTRODUCTION

The Tanzania mainland's healthcare system, through its ongoing health sector reforms, aims to improve health outcomes. As part of these reforms, the Ministry of Health developed its strategic plan—the Health Sector Strategic Plan V (HSSP V 2019-2024) as well as the Digital Health Strategy (2019-2024) to guide priority setting and deployment of resources in the health sector. The Ministry recognizes the potential of information and communication technology (ICT) in transforming healthcare delivery by enabling

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information access and supporting healthcare operations, management, and decision making. However, the Tanzanian health sector was characterized by a fragmented landscape of ICT pilot projects and numerous data and health information system (HIS) silos before 2013, with significant barriers to the effective sharing of information between healthcare participants. Although the government, partners, and private institutions are continuing to invest in various ICT initiatives, without some form of a national plan and coordination, there was a real risk of continued duplication, ineffective expenditure, and the creation of new solutions that cannot be integrated or scaled across the continuum of care.

However the Ministry as part of the e-Health Strategy (2013 - 2018) implementation, is in the effort to implement a national Health Information Mediator (HIM) which is an integrated Health Information System (HIS) that supports information exchange and sharing across the health sector. To achieve this venture, the Ministry with support from partners, formed a Technical Working Group (TWG) to work on the Health Information Exchange (HIE) project. The HIE TWG is divided into four sub teams working on specific tasks namely the Health Information Mediator (HIM), Care and delivery, Programmatic and Policy Decision Support, and Health Resources Management.

2 THE ROADMAP OF IMPLEMENTATION OF HEALTH INFORMATION MEDIATOR (HIM)

The Roadmap of implementation of Health Information Mediator (HIM) is organized in the following main components which address four corresponding questions;-

- Current situation which highlights where are we now?
- Vision which stipulates where do we want to be?
- Strategies and Functions which stresses how do we get there?
- Sustainability which focus on How do we stay there?

3 CURRENT SITUATION OF HIM IN TANZANIA

As part of the eHealth strategy implementation, the government of Tanzania with support of partners and technical agencies has made some progress in leveraging ICT to improve key aspects of the health system. To mention just a few, a Electronic Logistics Management Information System (eLMIS), has been deployed country-wide to manage requisition, distribution and reporting of health commodities, and the system is interfaced with the Medical Stores Department (MSD) Enterprise Resource Planning (ERP) system, Epicor 9; a Human Resource Health Information System (HRHIS) has been deployed country-wide to help manage health care workers at all levels in the Health Sector; a Routine Health Management Information System (HMIS) has been implemented using DHIS2 platform to support evidence-based decision making; a Health Training Institutions Information System (TIIS) has been implemented country-wide to strengthen and coordinate the human resource for health production data collection systems; a Health Facility Registry (HFR) has been launched as a shared information service that stores standardized health facility data including unique facility identifiers.

However, it is important to note that while each system in the aforementioned initiatives serves an important purpose, but each one has been driven by needs within a particular domain of the health system, making it difficult to address crosscutting needs. Thus to address immediate crosscutting needs, there have been efforts to integrate these various applications using point to point (system to system) integration approach. For instance DHIS2 has been integrated with eLMIS, HRHIS, and HFR, and Epicor 9 at MSD has been integrated with eLMIS, TIIS has been integrated with HRHIS, etc. While the point to point approach can be useful to address immediate integration needs for a small number of systems like two or three, but as more and more systems are added, it becomes very complex and costly to scale and maintain.

The implementation of the Health Information Mediator (HIM), apart from addressing the aforementioned challenges of point to point integration approach, it intends to accrue the following benefits to the health sector: Increased ability to compare data across domains and resources, Better visibility of anonymized patient level data, Improved integrated and longitudinal care, Increased citizen access to health

information, Increased continuity of care, Improved decision-making at the time of care and Client feedback based on care received

Tanzania has done a need assessment and developed requirements for implementing an interoperable solution in the country which will make all system to talk to each other in the health sector. This was followed by an acquisition strategy which ended by acquiring a Health-e-link solution from United states. Customization of this Tanzania Health Information Exchange solution began in January 2017 which was preceded by gap analysis which enhanced gap prioritization on three main areas cost, scope and time. Through the support of USAID Tanzania managed to configure and customize HIM where by up to now 8 system has been connected via HIM . Currently Tanzania is under testing phase of the HIM .

4 THE VISION OF HIE IN TANZANIA

Tanzania's HIE Vision: A common standards-based national scale eHealth architecture that enables the effective flow and sharing of information in support of the eHealth Strategy.

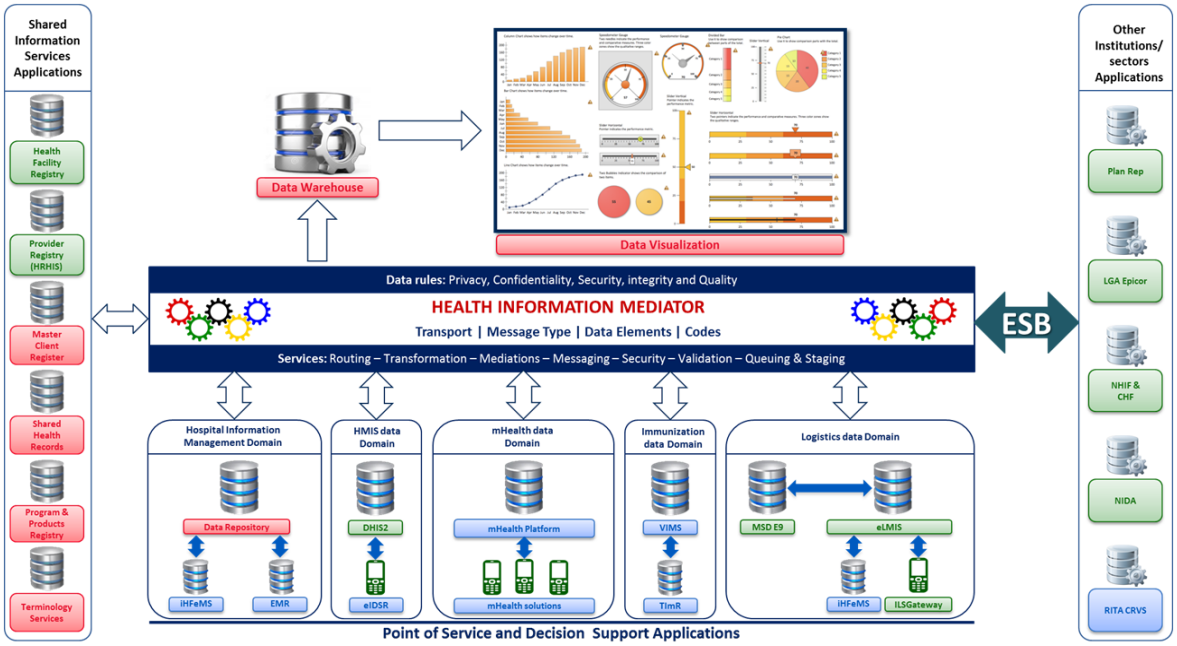
5 STRATEGIES AND FUNCTIONS OF THE HIM

Health Information Mediator performs three main functions which are:-

a) Facilitate the communication among the participating system
b) Reduce the number of entries from the Data sources which means you can create once and use many multiple times
c) Standardize data sharing among participating system by doing the following ways:-Validating, Entity matching, Reroute, Queuing and Staging.

In Validating Mediator cross check if sender data meets destination standard. While in Entity matching Mediator assures if sender data for instance has column of male and female and destination data has column 1 and 2 to signify male and female then the Mediator creates lookup table or cross mapping or macro or crosswalk table. Apart from Rerouting in which if you route certain transaction and it fails then Mediator reroutes to another alternative route. Differently in Queuing, Mediator prioritize requests if gets a high priority transaction for instance a referral transactions over a routine transaction. Lastly in Staging, mediator arrange transactions in a sequence way such as ascending order.

Below is the Health Information Exchange Conceptual Model



6 SUSTAINABILITY OF HIM

The implementation of HIM guarantee sustainability since it followed the Principle of Digital Development which are:- Design with the user, Design for scale, Build for sustainability, Be data driven, Use open standards, open data, open source, and open innovation, Address privacy & security, Be Collaborative.

However these Principle of Digital Development they are in line with the Tanzania Government Principle requirement for the Government to sustain any ICT system. Hence the Government will continually allocate resources to support ongoing activities of the implementation of HIM since it comply with Government standard.

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Journal of Health Informatics in Africa

Leveraging Google's Open Health Stack to Develop a Maternal Health Information System for Low- and Middle-Income Countries: The case of Mama's Hub

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Background and Purpose: According to the World Health Organization (WHO), mothers and children are among the most vulnerable populations, with their health being most susceptible to weak healthcare systems and health emergencies like pandemics and epidemics. The wide adoption of digital health solutions that are particularly characterised as digital public goods and global goods, presents an opportunity to improve maternal and child health by deploying low-cost, robust, sustainable and interoperable health systems.
Methods: IntelliSOFT leveraged Google's Open Health Stack (OHS), specifically the Android FHIR SDK, to develop a maternal health information system (MHIS) by digitizing the ANC component of the Mother and Child Handbook developed by the Ministry of Health in Kenya.
Results: By leveraging the OHS, not only was the duration of developing the provider facing mobile app of Mama's hub shortened to three months from an estimated nine months, the quality of the solution was significantly higher. The outputs of this project include Mama's Hub with three components: (1) A client-facing mobile app, (2) A provider-facing mobile app, and (3) A web app**.**
Conclusions: The adoption of open standards, technologies, architectures and content in developing digital health interventions has the potential to lower development costs and contribute to healthcare democratization, ultimately accelerating achievement of Universal Health Coverage**.**

Keywords: Maternal and Child Health, Open Health Stack, Digital Health

1 Introduction

According to the World Health Organization (WHO) classification, mothers and children are among the most vulnerable populations, with their health being most susceptible to broken and dysfunctional healthcare systems and health emergencies like pandemics and epidemics. While global maternal and child mortality rates have declined significantly over the last two decades to an average of 223 deaths per 100,000 live births, global health is still far from the target of 70 maternal deaths per 100,000 live births by 2030 as per the Sustainable Development Goals 3: "Good Health and Wellbeing" (1).

Similarly, neonatal and child mortality is still high despite reduction over the years, with WHO data in 2021 indicating 2.3 million neonatal deaths, down from 5.2 million deaths globally in 1990. These high mortality rates are attributable to the prevalence of infectious diseases, preterm birth complications, trauma, and lack of access to life-saving interventions, including safe delivery, quality postnatal care, nutrition, vaccinations, and primary care, among others (2).

The spread and advancement of information and communication technologies have been cited in the 2030 Agenda for Sustainable Development as one of the most promising drivers of human progress, including being a key enabler for UHC by improving and increasing access to healthcare (3). Digital technologies have also been identified as an enabler in adopting and implementing clinical guidelines developed by the

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WHO through the SMART (Standards-based, Machine-readable, Adaptive, Requirements-based, and Testable) guidelines approach. Indeed, countries worldwide are making efforts towards the digital transformation of health, with more than 120 countries having developed eHealth implementation strategies and policies, a significant indicator of global buy-in (4).

Mobile phones, including innovative and feature phones, with an estimated 7.33 billion mobile phone users to date, have accelerated the democratization of health, as evidenced by their adoption in primary health care and community health care programs globally (5). The recent COVID pandemic further accelerated the uptake of digital health with digital health solutions rapidly transitioning from a nice to have to a necessity3. An estimated 30% of Germans who seek regular healthcare services reported an increased use of digital health tools to access healthcare services. Mobile devices have eased data collection, consultation, follow-up, and referrals by healthcare workers and increased access to health information and health services for patients and clients, thus empowering patients to take charge of their health (6).

Free and Open-Source Software (FOSS) have been pivotal in advancing digital health transformation. They are founded on basic principles, including free redistribution and source code inclusion with its modification allowed with no restrictions or discrimination regarding use. FOSS has resulted in higher quality, reliable, flexible, and low-cost digital solutions that have powered digital transformation globally, with many governments deploying FOSS to support various public good functions (7). The health sector has extended FOSS to include free and open standards, architectures and content. Together, this approach portends greater promise of more effective digital health transformation. Specifically, this approach will provide solution developers with best in class technology toolkits based on industry best architectures and standards, and scientifically validated health content allowing them to exercise their innovation and creativity to build context specific digital health solutions that are sustainably maintainable. This approach will also facilitate information sharing, evolutionary development, and open collaboration, reducing the data silos that result from system incompatibility (8). Overall, this approach will lower health access barriers by making the development of digital health solutions faster and cheaper.

In this paper, we introduce Mama's Hub, a maternal and child health web and mobile app that IntelliSOFT Consulting Limited developed in collaboration with Kabarak University. The aim of Mama's Hub is to digitize Kenya's Ministry of Health Mother-Child Health handbook by developing a maternal health information system (MHIS) to collect, store, analyze, and disseminate maternal health data and information. The development of the mobile application leveraged the Android FHIR SDK, one of the components of the OHS which shortened the development time and resulted in a higher quality, more secure, offline capable solution. The system is mainly intended for use in underserved counties and vulnerable population groups in Kenya to support antenatal care (ANC) delivery, and ensure a positive pregnancy experience.

2 Materials and Methods

2.1 Open Health Stack

With a focus on standards, security, and sophisticated analytics, Google's Open Health Stack (OHS) is a collection of open-source components and developer resources created to speed up the creation of interoperable FHIR-based digital health systems with enhanced security and better data insights. Utilizing OHS components allows developers to focus more of their effort on creating cutting-edge digital health solutions rather than troubleshooting common technological issues. Components of the OHS which can be used independently or together include; Android FHIR SDK, FHIR Info Gateway science, FHIR Analytics science, Design Guidelines and, Developer Resources.

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In developing Mama's Hub IntelliSOFT used the Android FHIR SDK which is a compilation of Kotlin libraries developed by Google in close collaboration with the World Health Organization to facilitate the development of offline-capable mobile healthcare applications on Android using the HL7 FHIR® standard in support of the adoption of the WHO SMART guidelines. IntelliSOFT leveraged the three Android FHIR SDK libraries including; (1) the Structured Data Capture Library to facilitate the collection, validation, and processing of health data on Android (2) the FHIR Engine Library which stores and manages FHIR resources locally on Android and synchronizes with the FHIR server and; (3)the Workflow Library which provides point-of-care decision support and computes clinical quality measures on Android.

2.2 Software Development Life Cycle

The development of Mama's Hub was anchored on the Health Information System (HIS) Project Management Toolkit adapted from the US CDC Enterprise Performance Life Cycle (EPLC) that incorporates the best practices in HIS project management for facilitating optimal collaboration, coordination, and requirements gathering. The software development lifecycle based on the HIS PM toolkit has 5 phases that were adopted in the development of Mama's Hub, including (i) Inception and planning, (ii) Design, (iii) Development, (iv) Implementation (v) Maintenance. The Agile approach was employed throughout development to facilitate rapid and effective responses to changes and communication between all project partners.

As a gold endorser and one of the earliest implementers of the Principles for Digital Development, Mama's Hub was designed for and with the user with mothers and healthcare providers including community health workers involved in the design and testing phases to provide input into the features of the solution including usability, intuitiveness, and seamless workflows.

2.3 System Architecture

The development of Mama's Hub application was guided by the WHO SMART guidelines, with the system's building blocks including the health interventions and recommendations, user personas, database design, and business logic being derived from the WHO Digital Adaptation Kit (DAK) for Antenatal care. Figure 1 illustrates the overall Mama's Hub architecture.

Mama's Hub uses an offline-first FHIR-ready Android app that utilizes an FHIR SDK library - a platform whose development is being actualized by critical stakeholders in the digital health space, such as WHO (World Health Organization) and Google. Once data is captured on the forms, it is synchronized on the HAPI FHIR server, which serves as the data repository. Data capture forms are defined using FHIR questionnaires. Decision support rules, including alerts and reminders, are also built-in.

Figure 1 *Mama's Hub* Architecture

2.4 Data Dictionary

Based on a comprehensive review of the data elements in the ANC workflows and algorithms provided in the ANC clinical guidelines, the team developed a data dictionary in a spreadsheet outlining the clinical

content and decision support logic that was used in creating the data collection forms and facilitate the incorporated decision support workflows. The data dictionary was a core technical component in software development.

2.5 System Users and User Roles.

Community Health Worker ▪ Access both the web and mobile provider-facing apps. ▪ View assigned mother's records. ▪ Enter data on the MOH 100 form - referral to the facility.	**ANC Nurse** ▪ Access both the web and mobile provider-facing apps. ▪ Create and edit mother's records. ▪ Assign mothers to CHVs - referral back to the community. ▪ Generate reports.
System Administrator ▪ Access the web provider-facing app. ▪ Set up data such as facilities, and facility administrators. ▪ Create users & facilities. ▪ View their account information.	**Facility Admin** ▪ Access the web provider-facing app. ▪ Manage ANC nurses and CHV user accounts. ▪ Generate reports. ▪ View their user account information.
Pregnant Mothers ▪ Login ▪ View their ANC record. ▪ View next appointments. ▪ Receive SMS reminders on their upcoming ANC visits/appointments.	

3 Results

3.1 Outputs

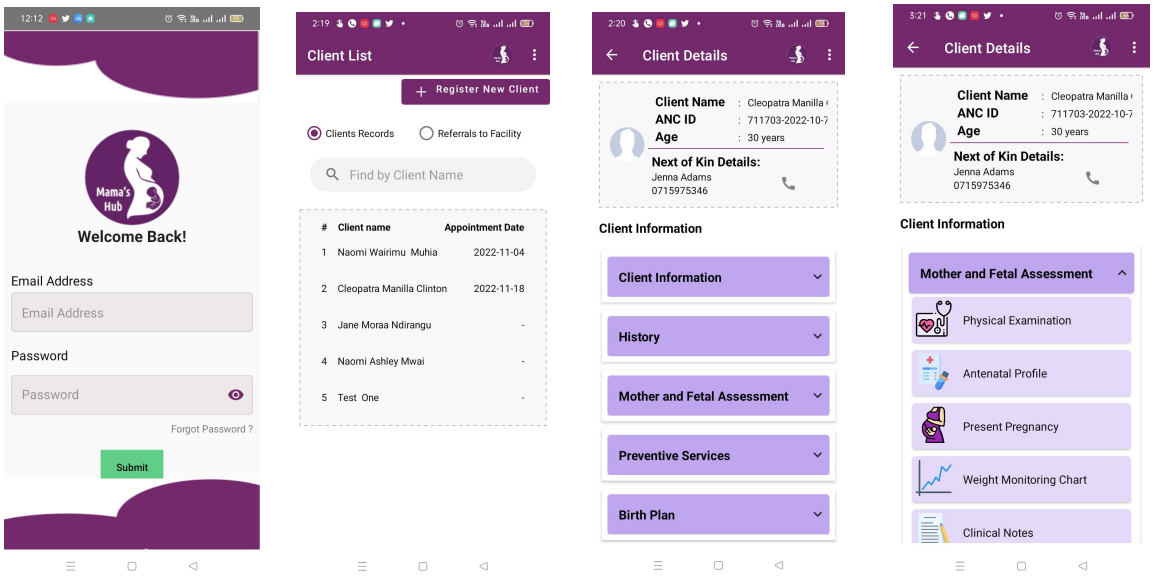
The method and approach described in section 2 resulted in a reference software dubbed Mama's Hub with three components, including (1) Client Facing mobile app, (2) Provider facing mobile app, and (3) a Web App. Technical documentation, including system design mock-ups, test cases, user scenarios, and user guides, were crucial outputs.

3.2 Client-Facing Mobile App

The client-facing mobile application is designed to serve as a personal health record for the clients. It allows the clients to log in and view their ANC health records and appointments. Clients registered on the app receive SMS reminders on upcoming ANC visits and appointments.

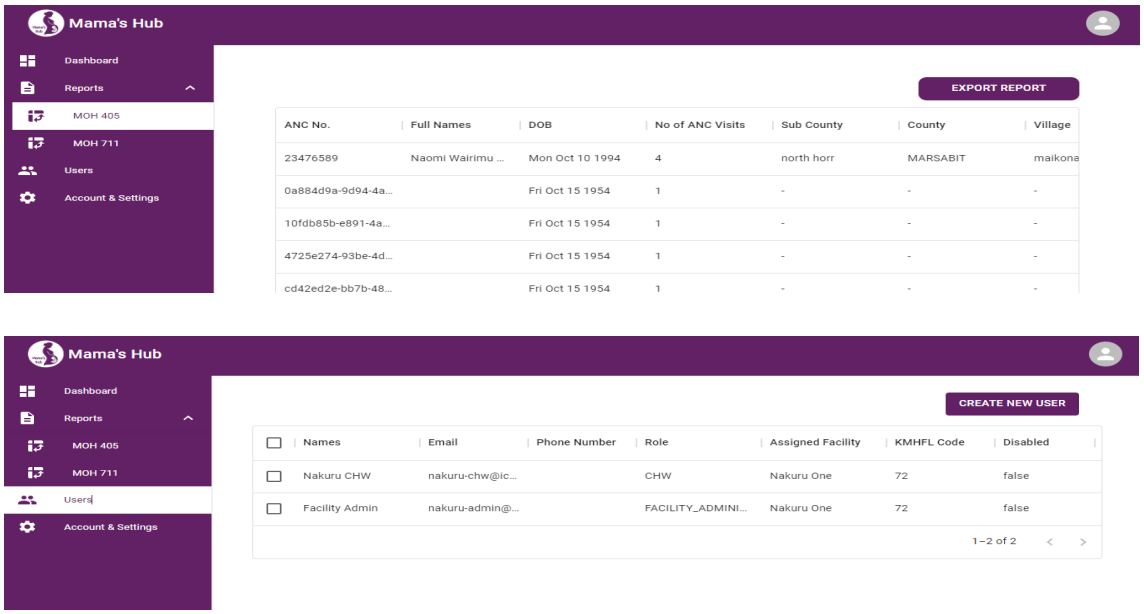
3.3 Provider Facing Mobile App

The provider-facing mobile application is designed for role-based access by users, including the ANC nurse, CHW, facility administrator, and system administrator, whose accounts are created and managed through the web application. The mobile application facilitates ANC service provision at the facility and community levels. The app includes clinical decision support, which aligns with the clinical guidelines for ANC provided by WHO and adopted by the MOH in Kenya. The provider-facing mobile app also allows appointment setup and facilitates the referral of patients in the community to health facilities by CHWs.



3.4 Web App

The web application is utilized at the health facility level for user management to create & edit user accounts, facility management to add new facilities that adopt the use of Mama's Hub, and to perform data capture on the forms while generating and exporting reports. It also features a dashboard that includes the MOH ANC reports and critical data points, including the number of ANC visits, the number of patients positive for syphilis, HIV, TB, and the number of clients who received Long Lasting Insecticide Treated Nets (LLITN).



4 Discussion

As health needs across countries continue to increase and get compounded by medical emergencies like pandemics, adopting innovative digital technologies in healthcare delivery is necessary. Despite their potential value in improving health service delivery, the prohibitive costs of developing custom applications from scratch limit their adoption, particularly in LMICs. This has resulted in the growth of OSS aimed at facilitating software development in an easier, faster, cheaper, and interoperable way (9).

By leveraging Google's Open Health Stack, IntelliSOFT built Mama's Hub's first version in under three months against the estimated nine months needed to build the app from scratch by providing APIs for syncing and offline capabilities as well as facilitating the conversion of FHIR questionnaires into forms through the in-built UI widgets. This also allowed the development team to focus on customizing the app through value-adding features instead of working through the foundational application infrastructure. Building on the FHIR standard facilitated interoperability with other systems in various facilities and contexts.Through the OHS, the development team built Mama's Hub using a common data model based on the HAPI FHIR Structures which enhances interoperability. The OHS also significantly shortened development time

By digitizing the previously paper-based records, health facilities and the Ministry of Health Care can view real-time information about referral flows. Having a digital referral form (that can be adapted easily) also ensures that the quality of referrals is consistent across the region and that healthcare providers can easily access the client's information and make informed decisions on the mother's continuum of care. The offline capability makes Mama's Hub ideal for Low- and Middle-income countries where it is intended for use.

Following development completion and user acceptance, testing (UAT) was conducted with end users in various facilities in Nakuru County. Their feedback was compiled and used to revise features in the system. This was a component of the user-centered design approach adopted throughout the project. The project team facilitated a trainer of trainers training to promote adoption and use of the solution.

The following steps in this project include the system rollout in more counties and facilities in the country to move it beyond the pilot phase. Adopting official MOH workflows and forms potentiate Mama's hub incorporation into Kenya's health system to ensure its sustainability with plans to integrate it with the Kenya EMR system. IntelliSOFT is developing the documentation generated into a DAK in line with the WHO SMART guidelines as part of Mama's Hub advancement.

Acknowledgments

Statement on conflicts of interest

The authors declare no conflict of interest.

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Transitioning from Traditional EMR to OpenEHR: A Case Study of the Impact on Clinical Workflows and Potential for Data Interoperability, and Quality Improvement Initiatives

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Background: This case study explores the transition process of EHA Clinics, a private primary healthcare network in Nigeria, from a traditional electronic medical record (EMR) system to an OpenEHR-based platform.
Methods: The study employed a questionnaire survey to assess the experience of clinical staff who have used both platforms. A total 14 staff Clinical staff met the criteria for inclusion based on the use of both the traditional EMR and the OpenEHR based platform.
Results: The results show a notable reduction in time spent on patient transitions and documentation and easier collaboration among clinical teams, leading to improved clinical workflow efficiency.
Conclusion: Our study results indicate improved clinical workflow efficiency and the potential for quality improvement initiatives and data interoperability with other platforms. Our experience provides valuable insights for healthcare organizations considering a similar migration, highlighting the benefits of the OpenEHR platform in streamlining clinical processes while acknowledging areas that require further attention, particularly in decision support and quality improvement initiatives.

1 Introduction

EHA Clinics, a leading private primary healthcare provider in Nigeria, recognized the need for a more advanced and interoperable electronic health records system to enhance patient care, and support quality improvement initiatives. The need for finding a new EMR arises due to several key factors, including limitations in scalability to accommodate multiple locations, slow database access speeds, high costs associated with the existing system, the absence of offline capabilities, and the inability to support Clinical Decision Support Systems (CDSS) [1] [2]. The decision was made to transition from a traditional EMR system to OpenEHR - an open-source, standards-based framework for electronic health records. This case study documents the transition process and evaluates the impact on clinical workflow, data interoperability, and quality improvement initiatives.

1.1 Objectives

The primary objectives of this case study are:

A. Assess the challenges faced during the transition from traditional EMR to OpenEHR.
B. Evaluate the impact of the transition on clinical workflow efficiency.
C. Highlight on potentials for data interoperability achieved through the OpenEHR implementation.
D. Highlight on potentials quality improvement initiatives within EHA Clinics.

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2 Methods

2.1 Transition Process

A. The transition process consisted of several key steps:
B. Evaluation and final selection of OpenEHR platform.
C. Customization of the OpenEHR platform to meet the specific needs of EHA Clinics.
D. Data migration from the traditional EMR system to OpenEHR.
E. Training and education for healthcare providers and staff on OpenEHR principles and usage.
F. Ongoing monitoring and evaluation of the transition process.

2.2 Data Collection

Data for this case study was collected through:

A. Interviews with key stakeholders involved in the transition process.
B. Questionnaire survey of clinical workflow and documentation practices before and after the transition.
C. Review of documentation and reports related to quality improvement initiatives.
D. Evaluation of data interoperability achieved through OpenEHR.

3 Results

3.1 Impact on Clinical Workflow Efficiency

The transition to OpenEHR resulted in several positive outcomes, including:

A. Streamlined documentation processes, leading to improved efficiency.

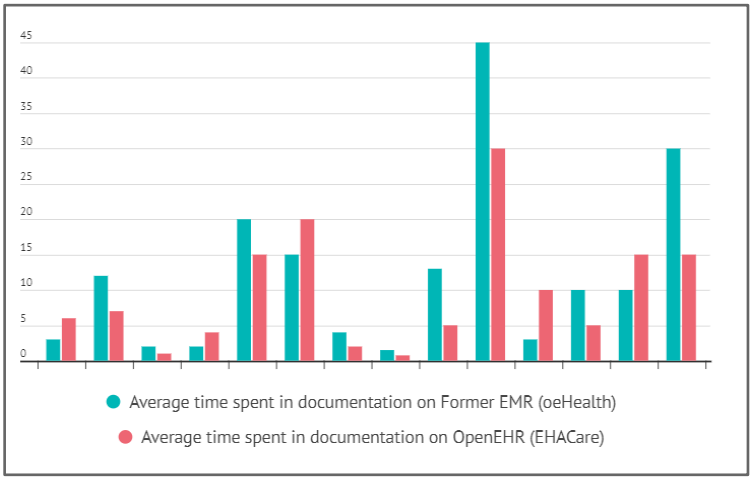

Figure 1: Responses on average time spent in documentation

B. Enhanced collaboration among healthcare providers through standardized data entry.

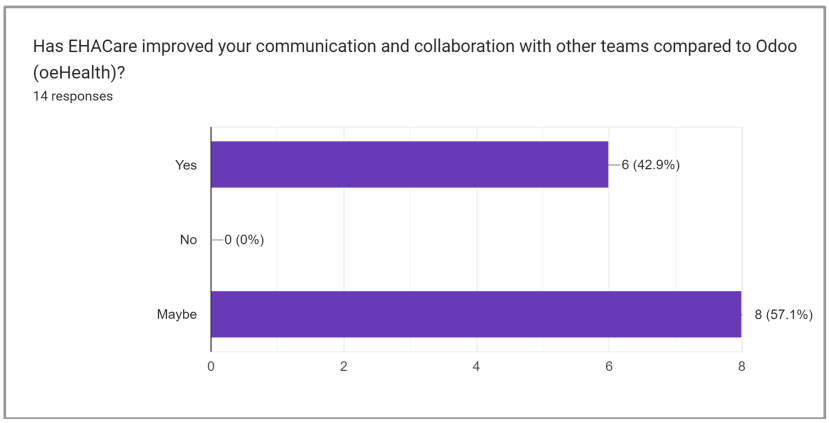

Figure 2: Responses on collaboration

C. Real-time access to patient data, enabling quicker decision-making and better care coordination.

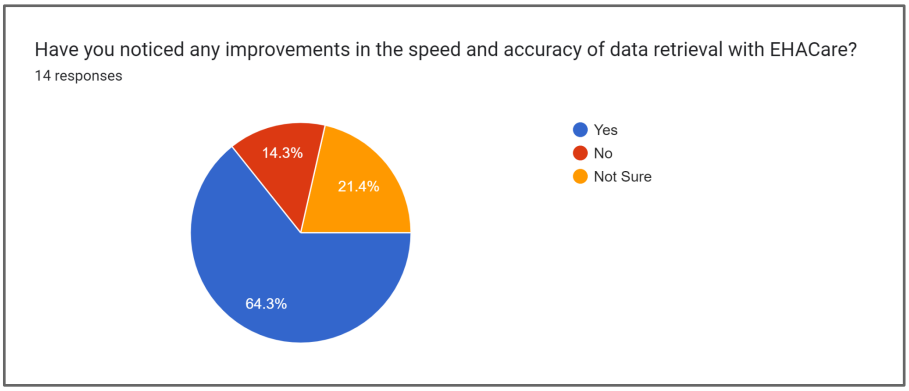

Figure 3: Responses on data retrieval

4 Discussion

4.1 Potential Impact on Data Interoperability and Quality Improvement Initiatives

Based on recent findings [1] [3], the OpenEHR implementation holds potential to impact data interoperability and quality improvement initiatives in the following areas:

4.2 Data Interoperability

A. Standardized data models, enabling structured and consistent data capture.
B. Improved data sharing for research and public health initiatives.

4.3 Quality Improvement Initiatives

A. With improved data accessibility, clinicians could generate detailed reports and analyze trends in patient outcomes, resource utilization, and clinical performance
B. Enhanced data analytics capabilities, can lead to improved identification of quality gaps and areas for improvement.
C. These insights enable the identification of areas for improvement and the implementation of evidence-based interventions to enhance the quality of care.

5 Conclusion

The transition from a traditional EMR system to an openEHR-based system has been a significant undertaking for EHA Clinics. However, the benefits of the new system in terms of improved clinical workflow have been significant and indicate potentials for data interoperability, and quality improvement initiatives. The organization will continue to refine and improve the system to maximize its potential in improving patient outcomes and enhancing the quality of care.

Looking ahead, EHA Clinics plans to further leverage the openEHR platform by incorporating advanced features such as clinical decision support systems, predictive analytics, and telemedicine capabilities. These developments are expected to further enhance patient care, clinical workflow, and overall healthcare delivery at EHA Clinics.

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Statements on conflicts of interest

The authors declare no conflicts of interest in relation to the findings and conclusions presented in this case study.

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Discharge summaries in routine patient records: potential for meeting needs for communication between healthcare providers to support NHI

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1 BACKGROUND

Whether in paper or electronic form, the discharge summary is an essential tool for supporting integrated patient care across and between multiple health care providers. The MbHIS-EVAL project aimed to review a sample of routine patient records from a sample of 44 hospitals in NHI pilot districts, to assess their suitability to meet NHI requirements.

2 METHODS

- Approximately 5 700 records from the 44 study hospitals were reviewed by trained fieldworkers. Data were recorded in a REDCap database.
- The format of discharge summaries in a smaller sample (N = 369) of the patient records was analysed to obtain an understanding of the extent to which the discharge summary formats in routine use in the study hospitals support the collection of sufficient data to inform communication between treating facilities when a patient moves from one hospital to another.
- These results were compared with data obtained from hospital informants for 34 of the 44 study hospitals, describing the required content of records in each hospital, including the expected presence or absence of discharge summaries.

3 RESULTS

- approximately 65% of routine patient records included discharge summaries
- A review of the formats of the discharge summaries in the sample of 369 records indicated that they contained between 4 and 7 standard components of a discharge summary, as defined in the study protocol. Most of the formats made provision for ‘main diagnosis’ and/or ‘discharge diagnosis’.
- 94% of hospital informants (32/34) reported that routine patient records should include discharge summaries.
- discharge summaries in electronic format were made available in only one of the study hospitals – a regional hospital in the Western Cape.
- 38% of hospital informants (13/34) reported that diagnosis data should be available in electronic format in patient records.

4 CONCLUSION

The use of discharge summaries to provide concise and standardised descriptions of inpatient care in the study hospitals is widespread, but not universal. The standardised formats in use indicate that hospital personnel responsible for completing discharge summaries should be familiar with the concept of providing patient information in standard format. However, the very limited availability of discharge summaries in electronic format indicates that significant efforts and resources will be required to ensure the availability of standard discharge summaries in digital format, to support the NHI.

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