Proceedings of the 13th Health Informatics in Africa Conference

HELINA' 21

JHIA online.org

PART I
Case Studies and Experience Papers

Leveraging Digital Health Interventions to Enhance Prevention, Response and Control of Public Health Emergencies in Low and Middle-Income Countries

Editors: Nicky Mostert, Ulrich Kemloh

ISSN: 2197-6902
ISBN: 978-3-948681-01-2

Publisher
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Journal of Health Informatics in Africa

Editorial to the HELINA 2011 Proceedings

Nicky Mostert
Nelson Mandela University, Gqeberha, South Africa

The 2020/2021 edition of the HELINA (HEaLth INformatics in Africa) conference was held from 18 – 22 October 2021 as a blended virtual and in-person conference in Kampala, Uganda due to the COVID-19 pandemic. The conference was hosted by the Uganda Health Informatics Association (UgHIA) in partnership with the Makerere University, School of Public Health, the Ministry of Health (MOH), Uganda and HELINA.

The conference theme focused on "**Leveraging digital health for public health emergencies within routine care in Low- and Middle-Income Countries**" and was inspired by the COVID-19 pandemic. The aim was to provide a platform to showcase interventions in the following areas:

- Digital health initiatives and implementations for public health emergencies, clinical care and surveillance;
- Maturity models, approaches and assessment tools for digital health evaluation;
- Community-level digital health solutions in public health emergencies;
- Health information exchange: Open standards, interoperability, data privacy and security, ethical considerations, policy & governance issues including legal and regulatory;
- Open Source Software in healthcare delivery, surveillance and public health emergencies;
- eLearning and digital health training for capacity building;
- Innovations for remote patient monitoring and care (Telemedicine); and
- Data science: big data and analytics in healthcare, surveillance and public health emergencies.

Review Process

The organizers of the conference invited original submissions in the following categories: full research papers; work in progress papers; or case study/experience presentations. A total of 44 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 based their final decision on the acceptance of each submission on the recommendations and comments from reviewers. Accepted submissions were then sent back to the authors for revision according to the reviewers' comments. This review process resulted in the following acceptance rates:

Full research papers: 43% acceptance rate (14 received, 6 accepted)
Work in progress papers: 80% acceptance rate (5 received, 4 accepted)
Case studies and experience papers: 88% acceptance rate (25 received, 22 accepted)

In order to be included in the conference proceedings, an accepted paper had to be presented at the conference, either virtually or in person. Authors also had to submit their final camera-ready papers after incorporating reviewer comments in order to be included in the proceedings. Unfortunately, only 5 of the 6 accepted full research papers, and 20 of the work in progress-/cases study-/experience papers were received and included in these proceedings.

Nicky Mostert
HELINA 2021 SPC Chair
29.12.2021

Journal of Health Informatics in Africa

Assessment of the Digital Health Maturity for select districts in Uganda

Priscillah Balirwa[1], Lilian Ayebale[1], Afra Nuwasiima[1], Brian Ssennoga[3], Kenneth Arinda[4], Inshallah Franco[4], Paul Mbaka[6], Carol Kamasaka[6], Jesca Nsungwa Sabiiti[6], Upenytho Geaorge[6], Caitlin Augustin[5], Hasifa Naluyiga[1], Jessica Oyugi[2]

[1] Living Goods, Kampala, Uganda, [2] UNICEF, Kampala, Uganda, [3]Medic, [4]BRAC Kampala, Uganda, [5]DataKind, [6] Ministry of Health, Uganda

1 Introduction

The Ministry of Health Uganda's Health Sector Strategic Plan 2000/01 – 2004/05 identified extending basic health services to the entire population as the major challenge to the healthcare system, which is very significant in rural areas where access to healthcare is limited. A contributory factor to this challenge is the inadequate human resources for health that are inappropriately distributed, with distribution of trained healthcare workers favoring urban areas1.

Cognizant of the above, Uganda established the Village Health Teams (VHTs) in 2001 with the aim of delivering the much-needed basic health care directly to communities in Uganda, hence closing the gap in access to healthcare at the last mile. VHTs who are members of the Ugandan communities are a key component of community participation and empowerment, enabling communities to actively take responsibility for their health, while linking them to the formal health service delivery system and bridging the human resource gap. [2]

Digital solutions present an opportunity to improve VHT performance, motivation and support. While thousands of small-scale mobile systems exist, many governments face challenges scaling these for greater impact. UNICEF in partnership with The Rockefeller Foundation and Living Goods-consortium including partners BRAC, Medic and DataKind supported Uganda's Ministry of Health (MoH) to assess the readiness to adopt digital solutions and define a pathway to readiness for implementation, scaleup and management of effective digital programs for community health.

2 Materials and methods

The assessment was conducted in five districts of Uganda, i.e. Yumbe, Ntungamo, Kasese, Wakiso, and Lamwo using the mobile health for Community Health Worker (mCHW)maturity model 3 . The districts were selected based on a criterion in consultation with MOH, UNICEF and consortium partners so as to leverage on existing community health initiatives in achieving the broader project objective while also capturing rich perspectives.

The mCHW maturity model is a Global Good that was co-developed by Living Goods, Health Enabled, the MoH in Uganda and Kenya and supported by funding from the Johnson and Johnson foundation. It is structured into three (3) domains: Domain (A), the CHW program itself. The second domain (B) covers the enabling environment of policy and technical infrastructure whereas the third domain (C) focusses on pre-existing CHW digital tools and technologies.

[1] https://afri-can.org/wp-content/uploads/2016/04/HSSP-2000-01.pdf

[2] Ministry of Health. Village health team: strategy and operational guidelines. Kampala: Ministry of Health; 2010.

[3] https://livinggoods.org/wp-content/uploads/2019/12/2190-LG-Assessment-and-Toolkit-v2.pdf

Each domain has indicators that interrogate the domain further, giving a total of 21 indicators (see table 1 in results section). The maturity levels are graded from a scale of 0-5 per indicator, where 0 is interpreted as the lowest maturity level where systems are inexistent and 5 is the highest level of maturity where systems are both present and functional.

A one-day workshop was conducted with the District Health Team (DHT) and political leaders in each of the 5 districts. Each workshop comprised 21 participants divided into 3 groups as per the 3 domains of assessment, each group assigned to score indicators in a domain.

3 Results

All districts were scored through the 3 domains for each of 21 indicators. A total score of 105 is equivalent to 100%. Yumbe district had the highest overall score of 40% across all categories, followed by Wakiso (36%), Kasese (31%), Lamwo (27%) and Ntugamo (22%). No specific domains uniformly scored as functional or better across all districts. The difference between highest and lowest district scores is 18%. No categories were uniformly scored well across all districts as in the table below;

Table 1. Domain, Component and Indicator scores of the mCHW maturity assessment

Domain	Component	Indicators	Scores -				
			Yumbe	Lamwo	Kasese	Ntungamo	Wakiso
A. CHW programme	A1. Existing CHW programme	01. CHW policy	5	3	3	3	5
		02.CHW Standards	2	1	2	4	2
	A2. CHW Skills	03. Skills of CHWs	1	1	1	1	1
	A3. CHW data	04. Data	1	1	2	2	1
B. Enabling environment: policy & technical infrastructure	B1. Leadership & Governance	5. Leadership & governance	1	1	1	1	1
	B2. Legislation and policy	6. Digital health policies and legislation	4	1	1	0	2
	B3. Funding for CHW digital health	7. Budget	1	1	0	0	1
	B4. Digital health capacity, implementations and standards	8. CHWs in dH policy	4	1	0	1	2
	B5. Technical infra- structure for CHW digital health	9. Infrastructure	1	1	1	0	1
		10. In-country software technical capacity	5	1	2	0	2
C. Existing CHW digital health	C1. Scale and scope of digital health for CHW	11. mHealth coverage	2	1	2	1	1
		12. mCHW Breadth	2	2	2	2	3
		13. mCHW Functions	2	1	3	2	5
		14. Client Interaction	2	3	2	2	2
	C2. Linkage with other health information systems	15. mCHW Integration	2	2	1	1	2
		16. Digitization of	1	1	1	0	1

		reporting					
	C3. Appropriate digital health for management & quality of CHWs	17. User-centred design	2	1	3	0	1
		18. mCHW Training	1	1	1	1	1
		19. mCHW Technical support	1	1	2	0	1
		20. Performance management	1	2	2	1	2
	C4. Operational logistics	21. Airtime and device management	1	1	1	1	1
			40%	**27%**	**31%**	**22%**	**36%**

4 Conclusion

The assessment revealed that maturity of digital health solutions for CHWs is at a nascent stage. There are opportunities to define engagement of district stakeholders specifically in co-designing an enabling policy, mobilization of district level budgets for CHW digital health and improving supporting technical infrastructure like electricity and internet connectivity.

5 Recommendations

Based on the current program maturity, it is recommended that the government starts with small formative digital projects and monitors progress in maturity of the various indicators to inform subnational and national scale. This should be an incremental scale approach informed by certain quality metrics at different checkpoints along the implementation journey.

Furthermore, such implementations should cater for all DESC components i.e Digitally enabling the VHTs with mobile applications that aid their decisions, Equipping them with necessary commodities and medicines, ensuring that they are Supervised and have clear targets to hit and finally, Compensating them based on their performance so as to motivate and empower them. The DESC Approach allows for Driving Impactful, Cost-effective Community Health Programs.

Journal of Health Informatics in Africa

Landscape mapping of Community Health Digital Interventions in Uganda

Brian Ssennoga[3],Priscillah Balirwa[1], Lilian Ayebale[1], Afra Nuwasiima[1], Kenneth Arinda[4], Inshallah Franco[4], Paul Mbaka[6], Carol Kamasaka[6], Jesca Nsungwa Sabiiti[6], Upenytho Geaorge[6], Caitlin Augustin[5], Hasifa Naluyiga[1], Jessica Oyugi[2]

[1] Living Goods, Kampala, Uganda, [2] UNICEF, Kampala, Uganda, [3]Medic, [4]BRAC Kampala, Uganda, [5]DataKind, [6] Ministry of Health, Uganda

1 Background

Uganda has been at the center of digital health innovation for nearly two decades, historically piloting digital technology programs for health care delivery. The fragmented landscape of pilots and volumes of data however presents significant barriers to effective sharing and use of information between healthcare stakeholders for decision making. To address this, UNICEF in partnership with The Rockefeller Foundation and Living Goods consortium including BRAC, Medic and DataKind supported the Ministry of Health (MoH) to map Uganda's community health digital landscape to inform insights for leveraging existing digital tools to optimize the use of community-level data and ensure scale in digital tools' development.

2 Methods

The digital landscape mapping was completed by undertaking a rapid review, employing methods by multiple global researchers such as Arksey & O'Malley, 2005 and Holeman et al., 2016. This process included several steps; 1) a landscape scan of digital health implementations in Uganda, identifying key digital health projects, actors, and relevant grey literature; 2) a search of peer-reviewed literature in Google Scholar; 3) defining and applying an inclusion/exclusion criteria to form a database of relevant material; 4) consultation with experts to identify additional material to refine the analysis.

This process of comprehensively mapping community level digital tools leveraged on work that has been done by MOH, UNICEF and partners, generating results that will become the standard reference for this landscape analysis at this snapshot in time.

For tools to be included under the list of digital tools scopped, they had to fall under one of the following categories that support community health system needs as defined by WHO's classification of digital health interventions. Exclusion was primarily based on tools belonging to a category that was marked as not supporting community health systems i.e categories E, K, R, S, T, U and Y as shown in the table below;

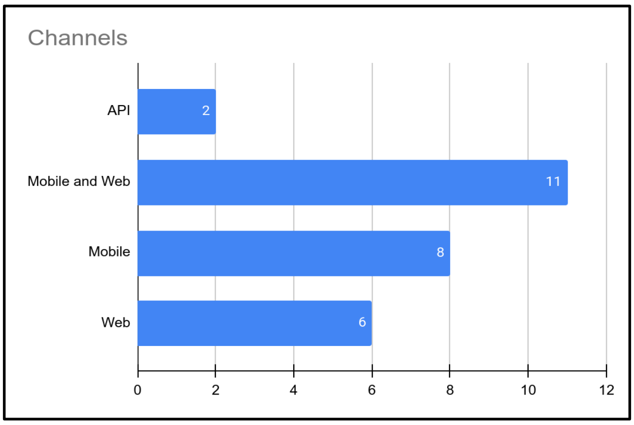
CODE	CATEGORY DESCRIPTION	Community Supporting Categories
A	Census, Population & Data WareHouse	X
B	Civil Registration & Vital Statistics	X
C	Client Applications	X
D	Client Communication System	X
E	Clinical Terminology and Classifications	
F	Community Based Information System	X
G	Data Interchange, Interoperability and Accessibility	X
H	Electronic Medical Records	X

I	Emergency Response System	X
J	Environmental Monitoring System	X
K	Facility Management System	
L	Geographical Information System	X
M	Health Finance and Insurance information System	X
N	Health Management Information System	X
O	Human Resource Information System	X
P	Identification registries and Directories	X
Q	Knowledge Management System	X
R	Lab & Diagnostics Information System	
S	Learning and Training System	X
T	Logistics Management Information System	
U	Pharmacy Information System	
V	Public Health and Disease Surveillance System	X
W	Research Information System	X
X	Shared Health Record and Health Information Repository	X
Y	Telemedicine	

3 Results

3.1 Type of Channels

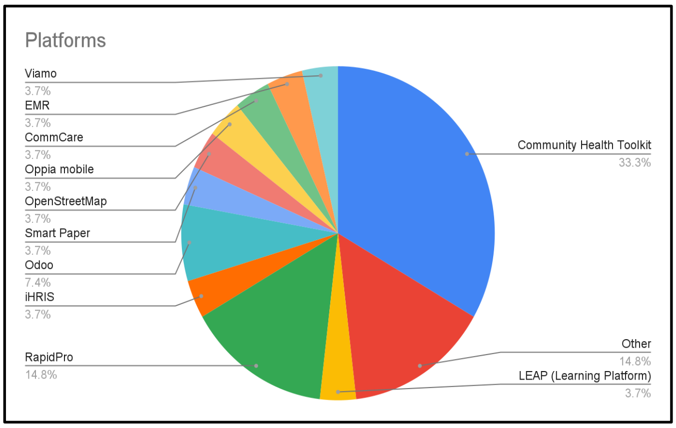
Many digital health tools that serve Community Health interventions are still in use within Uganda. Most are accessible from smart devices or web-browsers (6/27) and a couple are simply APIs (2/24). The use of mHealth tools is predominant even as the digital health maturity index is still at phase 24.



[4] http://index.digitalhealthindex.org/country_profile/UGA

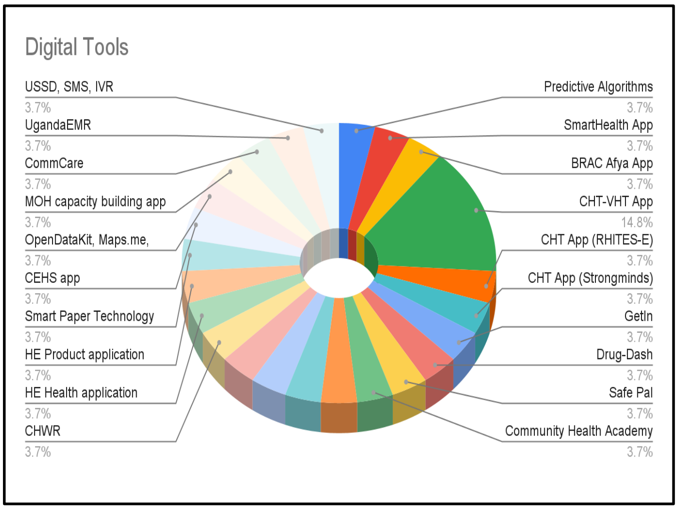
3.2 Tools

A Digital Health application may be capable of serving a single use purpose. Applications that are built as platforms can serve multiple digital health interventions.



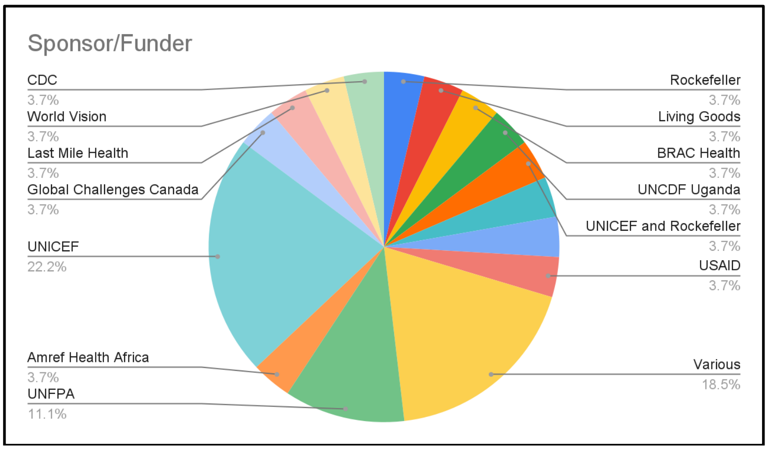
The leading platform deployments in the country include the Community Health Toolkit in 1/3 of the applications reviewed and RapidPro and a collection of web based platforms.

When evaluated for the tools these platforms support, there were a number in active deployment. For example, the Community Health Toolkit supports SmartHealth App; the BRAC Afya App both in use in private sector CHW implementations. RapidPro is used in mTRAC, Family Connect, the mHERO Connector and other USSD supported applications. Oddo is the platform of choice for Healthy Entrepreneurs' supply chain tools.



3.3 Actors

Whereas the WHO classifies users of digital health systems as Clients, Health Care Providers, Health Systems Managers and Users or Supporters of Data Services, in this assessment, we explored the actors associated around these tools in 3 buckets: Funders/Sponsors; Health Program Implementers and Digital Implementers.



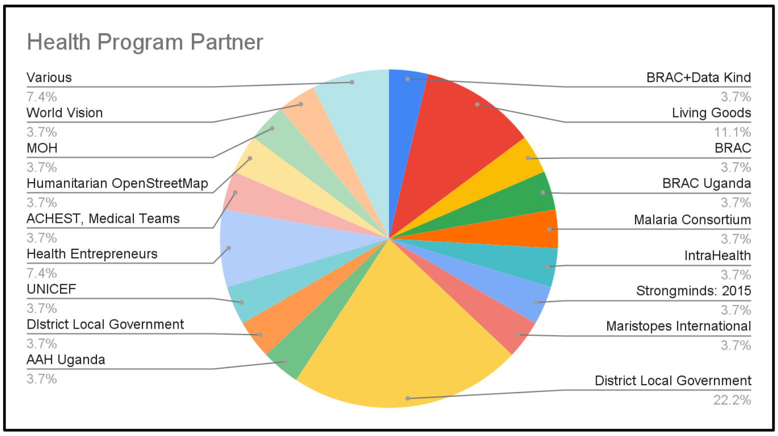
The bulk of the funding of community digital tools has come from development partners. Less than 20% of the funding has been mobilized by implementers (such as Living Goods, BRAC and Malaria Consortium). A couple of tools were supported by Innovation grants (Outbox).

A majority of the tools (56.8%) are funded solely by development agencies (with UNICEF funding about 46% of that) followed by Implementing partners (34.6%) and foundations (8.6%). At least 2 digital platforms (Rapidpro and Viamo's IVR) on which the tools are based have been implemented nationally across various programs.

3.4 Health Program Partners

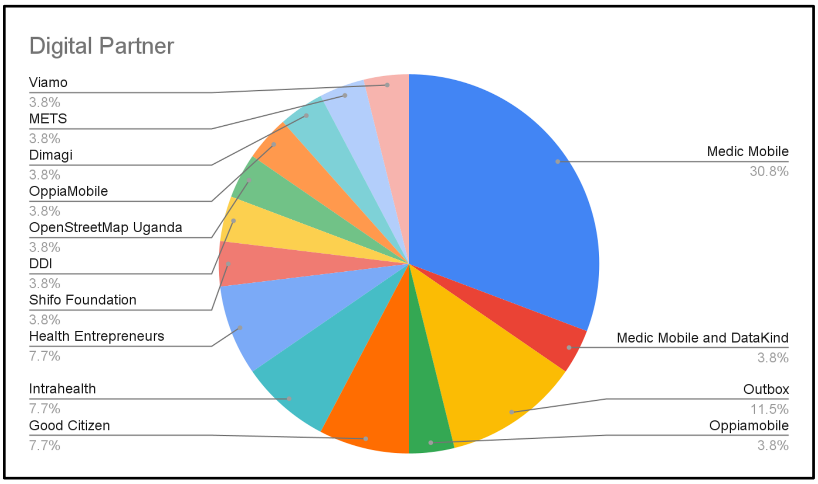
There are a number of household partners implementing digital programs within their community Health programming. When evaluated, a majority are not-for-profit long standing implementers in Uganda such as BRAC, Living Goods, Healthy Entrepreneurs in the private sector and; Consortiums of partners (such as those supported by UNICEF and USAID).

It is important to note that the District Local Government was identified as a key implementer. This is typical in solutions that were piloted or implemented directly with the districts, and in cases where the funding may have been channeled directly from the sponsor to support deployment at the district.



3.5 Digital Partners

The Digital Partner profile reveals organisations that are set up as technology service firms who are dedicated to supporting digital health implementations. In this assessment, a couple of international organisations stand out including Medic Mobile, Viamo, Intrahealth and Healthy Entrepreneurs. There are a couple of local organizations that stand out such as METS, Outbox, and Good Citizen.



4 Conclusions:

The rich landscape of digital health pilots presents an opportunity for Uganda to demonstrate a coherent approach to scale up digital health interventions. Platforms with national prevalence present an opportunity to foster interoperability and integration, hence enabling the utilization of data at national scale.

Keywords: Community Health, Digital Health, Uganda, mHealth

Journal of Health Informatics in Africa

Pathways to increasing trust in public health data: An exploratory analysis of CHW-collected data on the CHT platform evaluated for data quality and potential remediation

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1 Background and Purpose

Digital tools make it easier to collect data about patients closer to where they live, to understand their health needs better and to treat them faster, thereby saving lives. Community Health Workers (CHWs) are increasingly collecting digital data through the course of care delivery. Such routinely generated data provides information critical for providing appropriate and timely care, targeting specific health interventions based on predictive analytics, or deploying advanced algorithms to assess population health. However, despite widespread championing of digital health tools, the full impact of these technologies has not been realized because CHW-collected data is considered low quality and unreliable for data-driven decision-making. At a systemic level, mistrust in the quality of the data (a lack of so-called 'data trust') limits the potential impact. The primary objective of this work was to deploy a novel machine learning approach in order to identify inconsistent or problematic data (IoP) occurring across a digitally enabled CHW health system. This exploratory study was premised on the belief that all people deserve access to the latest health care delivery innovations, including data-informed care decisions and other forms of precision health. To provide first-class care to all people, there is a need to build confidence in data collected in the service of public health. However, quantifying and addressing data quality and completeness across projects are one-off, relatively high effort projects. In practice, data cleaning and documentation is often a bespoke process on any health platform, with little cross-project learning within or across platforms. Learning from the lessons of pilot programs (e.g. individual activities within one health practitioner system) the intent of this study is to assess data quality at a health platform level.

2 Methods

This exploratory study was situated in Uganda, using the Community Health Toolkit (CHT) platform. De-identified data was approved for secondary implementation research use. Data used represents routine care on a single deployment of the CHT provided by BRAC community health promoters (CHWs) through the community health promoter program. The study dataset contained 7,778,892 health encounters across eight health forms representing activities undertaken by 4,135 CHWs between Jan. 1, 2018 to Dec. 31, 2020. In total 787,580 individuals, and 394,917 households served were included in this study. Building on prior work by DataKind and Medic, data was analyzed using a variety of data science approaches including clustering algorithms, histograms, box plots, Sankey diagrams, and statistical testing. Tests for IoP were

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identified from a suite of 160 tests internally developed to identify IoP at the health platform level. All data was, and continues to be, stored in a relational database, and client data is protected following Medic's data security protocols.

3 Results

As anticipated, data exhibited issues with accuracy, completeness, and timeliness across health forms. Five major areas of deeper analysis and remediation were identified: IoP data throughout an interconnected system, accuracy of self-reported survey results, the potential miscalibration of measurement tools, completeness of maternal health coverage, and inconsistencies in CHW task completion. This study identified apparent systemic data quality issues that yielded inconsistent and/or problematic data. Unique among data quality review programs, this study demonstrated the effectiveness of data monitoring and assessment at a platform level, raising the bar for data quality assessments, reviews, and remediation in the sector. Furthermore, this study showed that data quality review could be as straightforward as debugging code, as data reviews can sit within a health application's existing workflow. In the same way that automated test suites can catch errors in software products and "debug", similar tests can be created to regularly and automatically flag IoP data across the datasets produced by CHWs. This platform-wide approach can track a wider range of data quality challenges than the usual front-end form validations in place on many health management platforms.

4 Conclusions

While each IoP issue identified could be individually remediated, recommendations are centered on a platform-wide (and tool agnostic) approach to data quality in community health. These shared results should be taken as representative of most CHW health encounters and the associated anticipated issues with digital data quality. For care providers, the ability to target treatment could be transformative. However, there is no hope for predictive analytics or algorithms for care delivery to succeed if the underlying data is untrustworthy. In other contexts, there have been inconvenient, disheartening, and devastating health outcomes of deploying algorithms based on weak data. Actors must commit themselves to the practice that further data science initiatives involving predictive algorithms, new uses of geospatial data, and other novel approaches to data-driven care be built on a strong foundation of systematically tested and trustworthy data.

Recommendations include fostering a sector-wide culture of data trust, prioritizing data trust in future software redesigns, enhancing the suite of provided data analytics, and providing CHW training focused on data trust and stewardship. These pathways for improvement have the potential to be developed and implemented at a platform-wide level, ensuring future data meets a higher standard of quality and that data trust increases as portions of a given dataset are validated. Encouragingly, all remediation pathways can be generalized and it is apparent that a solution would be most impactful operating within existing health care management tools such as DHIS2 and the CHT. Therefore, this study's results are interpreted to be recommended as platform agnostic, given the similarity of issues felt across platforms, geographies, and deployments when it comes to the completeness, accuracy, and timeliness of health data. As presented, these select results start to fill the frontline health sector's demand for precise information about data quality issues deployment or platform-wide.

This study aimed to provide results, discussion, and recommendations toward the creation of a toolkit inclusive of codebase, documentation, and training materials for auditing data quality and increasing data trust across health data platforms. Our hope is that when in use, it expands the capabilities of health platforms such as the one being developed by UNICEF in partnership with The Rockefeller Foundation and Living Goods consortium including partners BRAC, Medic and DataKind in support of Uganda's Ministry of Health (MoH) and the Village Health Teams program. The goal is for this toolkit to directly inform and support care coordination across the healthcare continuum and highlight the key role data systems play in enabling first-class care delivery in the hardest to reach communities.

Keywords: data quality, community health data, automated data quality

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Advancing Site-Level Health Informatics Capabilities Using a Maturity Model-Based Assessment Framework to Improve PEPAR Program Performance

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Keywords: Public Health Informatics (D040442), Maturity Model (no MeSH), Health Information Management (D063025), Health Information Exchange (D066275), Health Information Systems (D063005), Global Health (D014943)

1 Introduction

The PEPFAR-funded Global Informatics Collaborative (GIC) Technical Assistance Platform (TAP) is working towards improving public health informatics capabilities at the national, sub-national, and site (facility)- levels in the OpenMRS PEPFAR Collaborative (OPC) countries. Public health organizations need to become informatics savvy to leverage the potential benefits offered by public health informatics which aims to harness the benefits of digital technologies for improving public health outcomes. In order to become informatics-savvy, public health organizations require: a clear vision, strategy, and governance for information management and utilization; a skilled health informatics workforce; and well-designed and effectively utilized health information systems at all health system levels (Brand et al., 2018), especially at the site level.

Building on the Informatics Savvy Organization (ISO) framework for above-site levels in the public health system, TAP aims to develop, test, and implement a site-level (i.e. health facilities) ISO assessment tool that allows benchmarking, monitoring, and improvement in site level capabilities associated with three core capability elements of an informatics-savvy organization:

1. An organization-wide vision, policy, and governance for how the organization uses information and ICT as strategic assets
2. A skilled workforce
3. Effective information systems

Each of the three core capability elements has several specific capabilities, or "core essential elements", which the ISO tool assesses on a maturity model continuum. Assessment results are then used to develop an ISO roadmap with vision, strategies, operations, and tactics to achieve the desired future state.

2 Methods

We adapted Becker et al.'s procedural model for the systematic development, testing, and refinement of the site level ISO tool (Becker et al. 2009). The procedural model recommends specific steps such as problem definition, maturity model review and development strategy, iterative design, pilot, and maturity model use. TAP's objective is to improve site level informatics-savvy capabilities to enhance PEPFAR program performance. We conducted a review of available maturity-model based frameworks and tools.

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The review process and identification of core essential elements followed an iterative process involving bi-weekly consultation with experts within the TAP consortium. Key resources include:

PEPFAR' Site Improvement through Monitoring System (SIMS) assessment tool; Data Use Community's site level data and systems maturity framework; HIV/AIDS Sustainability Index and Dashboard (SID); PEPFAR Strategic Information Capacity Assessment Tool (PSICA); UNAIDS Privacy, Confidentiality and Security Assessment Tool; WHO SCORE for Health Data tool; HIS Stages of Continuous Improvement (SOCI) toolkit; and HIS Interoperability maturity toolkit.

Site level core essential elements (CEEs) for health facilities were developed based upon the results of the review process and expert consensus, along with a corresponding site level self-assessment tool, maturity model scoring framework, and protocol. Country team feedback was solicited and integrated into the final versions of the tool and protocol, which will be tested in two pilot countries during June to August 2021. Pilot results will serve both as baseline data for informatics improvement projects and to guide refinements to the site level assessment tool, protocol, and data use process.

3 Preliminary Results

We conducted framework crosswalks and questionnaire and capability maturity model-based response option crosswalks. These crosswalks resulted in mapping of site-level CEEs with above-site CEEs. Based on crosswalks we identified appropriate site-level CEEs; desk review findings indicate that there are overlapping core capabilities between above-site and site-level informatics-savvy organizations, though the CEEs vary in terms of specificity and granularity. For example, data exchange across different health data systems and among different healthcare organizations is essential to meet the diverse data needs of healthcare providers, public health administrators, program managers, policymakers, and researchers at the national, sub-national, and facility or site levels. The findings show that there is a lack of validated and well-defined indicators to measure and monitor site level (health facility) capabilities associated with the three ISO core capability elements. The findings also highlight a gap in informatics capability measurement as most of the available maturity model-based tools focus on data use or health information system capabilities such as digital readiness and information system improvement strategies rather than the broader informatics capacity of an organizational unit.

In addition to results from crosswalks and site level CEE identification processes, we will present anonymized results from site level pilot assessments conducted in one to two project countries as part of our HELINA case study presentation. We plan to present our pilot results in a process review format to demonstrate lessons learned from: the planning and implementation of the site level self-assessments; site level assessment team consensus scoring for each CEE; assessment result review and data use processes to develop an ISO roadmap to build informatics capacity where current weaknesses are identified; and recommendations for refining the final versions of the ISO site level CEEs, self-assessment tool, and protocol.

4 Discussion

Digital tools used at the health facility level, such as EHRs, strengthen health systems and improve access, equity, safety, and quality of health services. The newly released global strategy on digital health of the World Health Organization (WHO) calls for developing a national digital information technology (IT) infrastructure that enables seamless exchange and processing of health data-which is primarily generated by the healthcare providers- for use by the healthcare providers, the public health authorities, teaching, and research institutions (WHO, 2020b). The site-level ISO tool aims to assess and enhance the informatics capability at a level where digital health technologies such as EHRs are considered an essential foundation of the health services oriented digital health framework (Liaw et al., 2020). The self-assessment results are not the end result themselves, but rather facilitate informed and strategic planning to address informatics capability gaps.

5 Conclusion

The core capabilities outlined in the ISO framework are essential prerequisites for any public health organization committed to leverage the potential benefits of digital health technologies. Further, the journey to become an ISO is a continuous and adaptive learning process and unique for each public health organization. The site level ISO self-assessment toolkit enables health facilities to systematically assess their current informatics capacity, uncover strengths and gaps, and develop actionable plans to enhance their public health informatics capabilities and ultimately improve PEPFAR program performance.

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Implementing Adaptive Low-cost Knowledge Integration Platform-Uganda Experience

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Keywords (MeSH): Public Health Informatics (D040442), Health Information Management (D063025), Health Information Exchange (D066275), Health Information Systems (D063005), Global Health (D014943)

1 Background

Integration of data captured and stored in disparate health information systems (both electronic and paper) is critical to harness the benefits of investments in digital technologies to facilitate agile and adaptive decision making in low-resource settings (WHO 2020b). Most of the low resource settings (especially in the lower- and middle-income countries) lack health information system (HIS) interoperability and have limited digital infrastructure. Further, lack of digital workforce and financing are other key barriers to developing an agile and robust information system to empower policy makers, program managers, researchers, and service providers to access and use integrated datasets for delivery of public and private services including healthcare (Payne et al., 2019), education, agriculture, environmental and livestock related services. The Adaptive Low-cost Knowledge Integration Platform (ALKIP) has the capability to offer integration services to all key development sectors. To start with, the platform is being used to demonstrate value propositions to the healthcare sector.

2 Agile Method

ALKIP was developed by a local digital entrepreneur as an open-source platform using agile processes in a holistic ecosystem that included government, non-profit organization, and a digital health researcher. The process involved testing the prototype with the Uganda Ministry of Health and the HISP Uganda program and updating the integration platform. After thorough testing, ALKIP was adopted to integrate the electronic logistics management information system (eLMIS) by the Health Information Systems Program-Uganda. The implementation design included collecting data from the implementation and using it to resolve technical issues and provide user support.

3 Results

Currently, Health Information System Program Uganda (HISP Uganda) developed the eLMIS app, using the ALKIP platform, and is being implemented at a national scale to all facilities (more than 5000) ordering antiretroviral, laboratory, reproductive health, Tuberculosis (TB) first line, TB MDR and Test kits. It is being used in three warehouses: Joint medical stores, national medical stores and medical access Uganda limited. The platform allows apps to seamlessly be integrated into DHIS2, a software platform most ministries of health use for routine reporting without any additional configuration. ALKIP is a platform that

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acts as a mediator/interoperability layer which allows apps built using its application programming interface to be compatible with DHIS2. eLMIS app is one of the applications while health information stages of continuous improvement, integrated disease surveillance registry (IDSR), air quality, and location registry are few of the other applications in the ALKIP platform. Data stores, hosted applications manager, micro services manager, schemas and mapping manager, ALKIP interoperability layer, and external applications are the key components of the architecture (Figure 1).

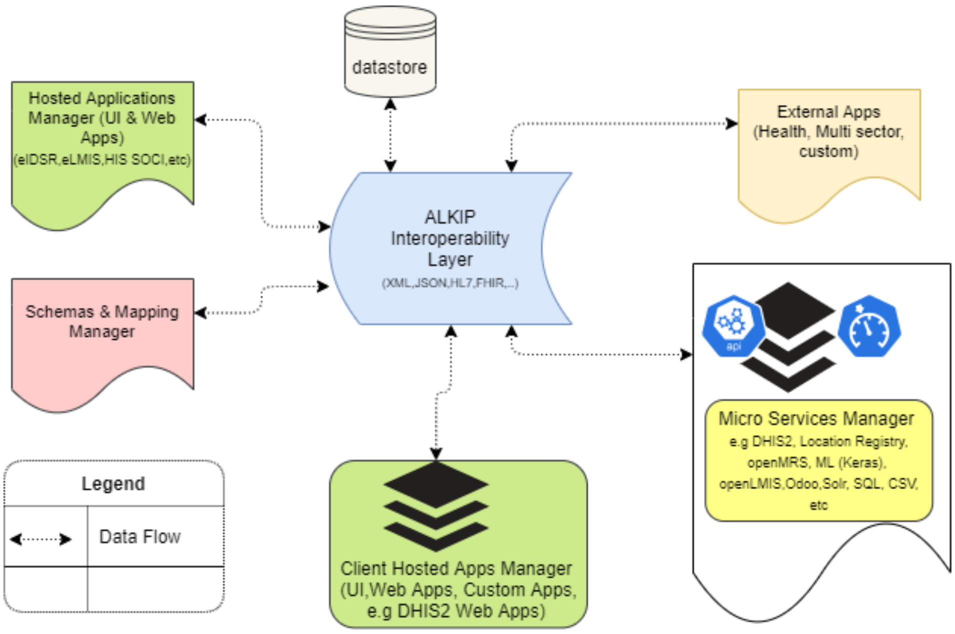

Figure 1. ALKIP Architecture

4 Discussion

ALKIP has the potential to become a global good over the period of time. However, it will require a community of practice and a sustainable financing model (Israr and Islam 2006). Studies show that flexibility and scalability (Braa et al., 2010) are integral to the success of a software platform and ALKIP offers both. Challenges in implementation of ALKIP applications in DHIS2 include DHIS2 datastore inability to be searched thus generating high downloads which affect the performance of reports generation. Countries that prefer using DHIS2 data store, can adopt the ALKIP data store as a micro service to overcome this challenge.

5 Conclusions

The Ugandan experience with the implementation and use of an integrated knowledge platform has the potential to guide its application in non-health sectors. Further research to explore its feasibility and applicability in integrating applications from agriculture, livestock and environmental sectors will showcase its value agnostic to any development sector.

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OpenMRS in 2021

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Abstract. OpenMRS is an open source electronic medical record system platform focused on the needs of resource-constrained environments along with a worldwide community of implementers and developers who are leveraging and contributing to a shared Global Good to address healthcare challenges. The past year, with the COVID-19 pandemic, has brought many challenges, but also many opportunities and the OpenMRS community has re-invented itself in the process. Efforts in 2021 are focused on unblocking more global collaboration through a new frontend framework, improving reporting capabilities, further embracing standards, and improving metadata management and deployment conventions. There are a growing number of opportunities for organisations and countries to use OpenMRS to improve patient care both locally and worldwide, to perform research, and contribute to a Global Good in ways that will ultimately optimise collaboration and reduce duplicated costs.

Keywords: open source, electronic medical records, community

1 Background

OpenMRS is an open source electronic medical record system platform focused on the needs of resource-constrained environments along with a worldwide community of implementers and developers who are leveraging and contributing to a shared Global Good to address healthcare challenges [1]. The OpenMRS platform is a Java-based web application that has been adapted for a wide variety of uses across dozens of countries since its first deployments in 2006.

2 Successes & Challenges

As for all other organisations, 2020 brought many challenges to the OpenMRS community and with these came opportunities. During the rise of the COVID-19 pandemic, the OpenMRS community responded by organising efforts within and among the community. New COVID-19 concepts were quickly added to our shared dictionary, OpenMRS was quickly adapted to address stresses to the healthcare system [2], country-level efforts and experiences were shared within the community [3] and with the global health community [4]. These examples demonstrated how vertical solutions (like HIV testing and case reporting) within a horizontal platform like OpenMRS could be rapidly adapted to meet new clinical challenges.

The OpenMRS community also re-invented itself in 2020 to take a more pragmatic approach to advancing its Global Good governance with the creation of a Technical Action Committee (TAC) and the development of squads. Squads comprise members of two or more organisations, along with community volunteers, who focus on working together to solve specific, shared problems. The community helps facilitate the efforts of squads with project management, OpenMRS Fellows, Google Summer of Code (GSoC) projects, and awareness of efforts within the community through community forums and Squad Showcases [5]. In December 2020, OpenMRS held its first virtual implementers conference [6] with the theme "Walking Together to Solve Emerging Health Challenges." There were 433 attendees from 35 different countries.

3 Road Map

Current efforts within the OpenMRS community are focused on unlocking more robust global collaboration. This is critical because on-the-ground eHealth implementers face growing demands with unmatched funding, especially amidst the global pandemic, making cross-organisation collaboration more important than ever to deliver on-the-ground needs for both caregivers and public health officials. To enable this degree of practical, scaleable re-useability we have prioritised building a new, modernised frontend framework, building the foundation for reporting at scale, further embracing the HL7 Fast Health Interoperability Resources (FHIR) standard [7], improving metadata management through investment into the OpenConceptLab framework for improved concept management, and the development of deployment conventions.

4 Opportunities

There are plentiful and growing numbers of opportunities within OpenMRS to improve patient care both locally and worldwide, to perform research, and contribute to a Global Good. Funders and countries are beginning to appreciate the importance of Global Goods and the benefits of customisable, standards-promoting frameworks to facilitate interoperability and reuse functionality across implementations. While large scale research studies have benefited from the interoperability of data across OpenMRS implementations, there are many more questions to be answered around system evaluations, cost of ownership, and implementation science.

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Care:Bricks - An LMIC-First Implementation for agile development of process-centric and guideline-driven point of care EMR systems

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Background & Purpose: The ability to reinforce clinical guidelines to optimize quality of care is a driving factor for electronic health records implementation. Digital systems that ensure completeness of data required for health programs, especially HIV, are now commonplace in most low- and middle-income countries. However, these systems are designed more toward supporting monitoring, evaluation, and reporting activities with clinical care support and guideline adherence often added as an afterthought. These systems also require dedicated developers and are difficult to upgrade as clinical guidelines change. This manuscript describes the rationale and prototypical implementation of a set of tools for rapid design and deployment of point of care, electronic medical record systems.
Methods: We outline a system of flexible components designed to support effective integration of clinical guidelines in LMICs. To minimize hardware costs and provide a system that users with low computer literacy can quickly learn to use, the system is also designed to run on small, low-power, touchscreen-enabled devices.
Results: We developed Care:Bricks, a set of modular tools divided into four components: a design environment based on a graphical workflow editor, a runtime environment to execute the design at a health facility at the point of care, a data representation and storage engine, and a core development environment.
Conclusions: Adapting electronic systems to changes in clinical guidelines is often slow and expensive. Agile, scalable, and low-cost implementations that a system like Care:Bricks can support offer a new model for sustaining EMR implementations in low-resource settings where employing dedicated developers is costly or impossible.

Keywords: EMR, EHR, Clinical Decision Support, Digital Guideline Implementation, Digital job aid, Digital health

1 Introduction

1.1 Clinical Guidelines

Clinical guidelines are a common mechanism for standardizing and improving the quality of care by synthesizing available biomedical knowledge into clear, reliable, reproducible, and applicable steps or instructions [1] [2]. The Institute of Medicine defines clinical guidelines as “systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances” [3]. Clinical guidelines have many potential benefits such as improved health outcomes for patients, increased quality and consistency of clinical decisions by healthcare practitioners, and reduction of healthcare system costs [4]. Despite the benefits offered by good clinical guidelines, uptake and adherence remains a challenge [5]. Patient preferences, lack of clarity, clinically inapplicable instructions, and a resistant organizational culture are some of the reasons that contribute to low utilization and uptake of clinical guidelines [1] [6].

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1.2 Job Aids

One common way to improve the clarity and utility of published guidelines is through job aids. Job aids are any external resources used to support the performance of a task by guiding, directing, and enlightening performance of an activity or decision [7]. Job aids can simplify complex guidelines, improve clarity of instructions and condense information into memorable snippets to support healthcare providers. Job aids have been particularly useful in low-resource settings where critical human resources shortages have necessitated task shifting from highly-trained staff to capable, untrained assistants [8].

A more enhanced version of a job aid is the use of computer systems to provide clinical decision support (CDS). Similar to how clinical guidelines inform decision making by healthcare providers, CDS systems provide targeted clinical and contextual knowledge such as patient and other health information to enhance the decision-making process [9] [10]. Unlike paper job aids, CDS systems can utilize and synthesize a wider range of knowledge to provide greater insight during a clinical consultation. However, CDS are just another form of a job aid i.e., digital job aid, and are not meant to replace people [11].

To increase their impact, job aids should be designed to seamlessly integrate and improve clinical workflows. Friedman [12] asserts that the development, implementation, and evaluation of such tools belongs to the field of informatics. In his seminal papers describing the field of informatics, Friedman [11] [12] argues that informatics is about placing information resources in the hands of users such that their performance or experience is better than when the information resource was not available. This assertion is a fundamental theorem of biomedical informatics and a guiding principle for this approach. To achieve this, Friedman [11] argues that information resources must be built for the benefit of people and offer something that the person doesn't already know or have. In other words, systems must make the work of healthcare providers easier, better, faster, or more satisfying. This can be attained if systems are designed from both a user- and process-centric perspective with the aim of improving workflows first rather than merely collecting data. Improving processes is an often-forgotten aspect of electronic systems especially in low-resource settings where data capture typically becomes the primary focus of digital systems rather than data as a by-product of clinical decision support.

1.3 Clinical Guidelines in Low- And Middle-Income Countries (LMIC) EMRs

Douglas et al. illustrate Friedman's theorem with their electronic medical record (EMR) system implementation, BART (Baobab Anti-Retroviral Therapy), where the healthcare provider is stepped through a series of questions drawn from Malawi's Antiretroviral Therapy guidelines using a wizard-style, single question per screen touchscreen user interface [13]. This approach allows the healthcare provider to recall and incorporate aspects of the clinical guideline into a natural discourse with the client while at the same time enforcing a standard workflow. As a result, this approach not only improves care, but also improves the process through which complete data are collected. The wizard design simplifies complex processes and enforces a clear sequence of steps with each step displayed as a single screen showing only pertinent information, focussing user attention and decreasing odds of user error [14].

Unlike other fields, scientific knowledge and healthcare practices change quickly. For example, in HIV care, clinical guidelines undergo frequent revisions due to changes in available interventions and changes in evidence on the benefits and harms of the interventions among others [15]. As such, systems built to support this work, like BART, must keep up with the changes or risk becoming obsolete. For example, when medication regimens change, the software needs to reflect those changes immediately, and any delay can result in the old regimens being perpetuated, with associated risk to patients. For systems like BART, adapting to such guideline changes required software developers to edit code and deploy changes, which may be extensive depending on the scale of the guideline update. The lead software developer for the BART system indicated a best-case scenario for incorporating revisions to the national ART guidelines requires three to four weeks of work for four professional software developers [16]. Reducing or eliminating the need for programmers to make adaptations with each change to the clinical guidelines could help better manage transitions between clinical guidelines and save significant time and resources.

In this manuscript, we describe a novel suite of tools designed to reduce dependence on software developers to both create as well as keep systems up to date with rapidly changing clinical guidelines and settings. This suite of tools has been designed and implemented to demonstrate the LMIC-first approach to developing EMR systems which is characterized by six themes namely; democratized EMR development, process- and guideline-centric, point-of-care, touchscreen-first, low cost, and low power.

2 Materials and Methods

We conceptualized Care:Bricks as a suite of four components for the effective use of clinical guidelines in LMICs: a design environment, a runtime environment, a data representation & storage engine and a core development environment. To minimize hardware costs and provide a system that users with low computer literacy can quickly learn to use, Care:Bricks is designed to run on small, low-power, touchscreen-enabled devices with minimal systems resources such as Raspberry Pis and other single board computers. All external software components are based on open source projects and Care:Bricks itself is licensed under the MIT open source licence [17].

2.1 Design environment

The design environment is a tool for LMIC Ministry of Health (MoH) staff to create and edit workflows that provide clinical decision support using clinical guidelines in a web-browser. We built the design environment on top of the NodeRed workflow editor [18], which is a visual environment for flow-based programming. This visual environment reduces the need for LMIC Ministry of Health staff to write code, enables reuse of common building blocks ("bricks") and makes a clinical guideline workflow inspectable by both the designer and other colleagues in MoH.

2.2 Runtime environment

The runtime environment is software deployed at a facility that takes workflows created in the design environment and transforms them into an EMR with wizard-style, touchscreen user interfaces for frontline healthcare workers. On the server-side, we programmed the runtime environment with an event-driven, asynchronous JavaScript approach through a minimal Node.js layer with optional data persistence. Web browsers on the client-side utilize modern Web-APIs (like Client-Storage and Multimedia components) through a simple JavaScript foundation in combination with discrete HTML/JS pages.

2.3 Data Representation & Storage Engine

We use JSON structures (an open standard file format) as the internal data representation. The bricks operate on these structures as the flows are executed by the runtime environment and data inputs are recorded through user interaction. At specific points the data structures are transferred to and stored on the server. Care:Bricks provides a simplistic file storage engine ready to be used in many simpler use cases. If a more sophisticated persistence layer is needed, additional database support is possible.

2.4 Core development environment

The development environment is a toolkit for developers that wish to modify and extend the Care:Bricks system. We provide application programming interfaces (APIs) and the source code of the existing system as a basis for custom extensions. We expect that LMIC MoH staff who master the design environment will desire enhanced functionality, the ability to create novel workflow modules that are not present in the base system and share their innovations with others.

3 Results

3.1 Design environment

The user interface for the design environment consists of a brick library on the left and a construction area on the right. Bricks, representing discrete steps in a flow, are dragged from the brick library into the construction area. Care:Bricks includes a library of bricks for the most common EMR usage scenarios in the brick library. Flows are a series of interconnected bricks (see **Error! Reference source not found.**).

Each flow has one or more starting, intermediate and ending bricks. Once bricks are placed in the construction area, they can be connected in the desired sequence by dragging a connection from the right side of a brick to the left side of another brick. Once the workflow is completed, the deploy button in the top right corner stores the workflow definition, from where it can be read by the runtime environment and rendered as a series of user interface screens.

Starting bricks allow a user to select a patient i.e., using a search screen or via a queue of patients in the waiting area or registering a new patient. A designer uses intermediate bricks to display summary information (e.g., as a graph or table), collect new data (e.g. height and weight), make a clinical decision or calculate a value (e.g. body mass index or prescription dosing). Ending bricks take the data obtained in a workflow and send it elsewhere (e.g., to the storage engine, another workflow or to another service).

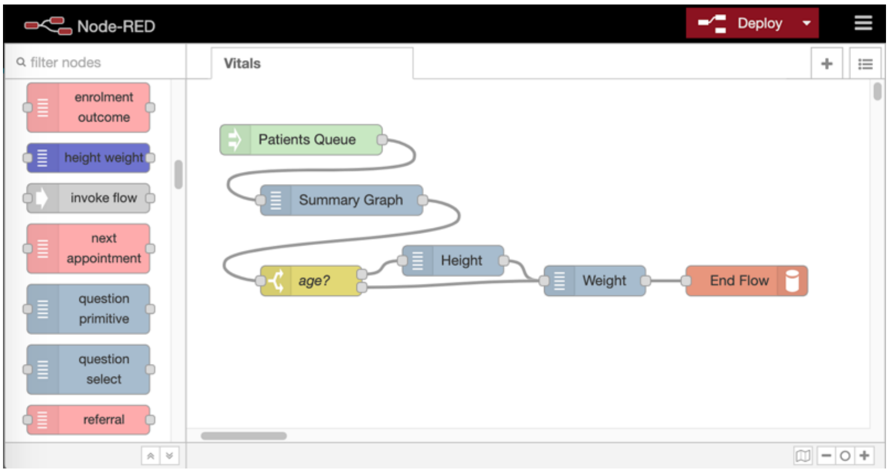

Figure 1. Design environment with simple vitals flow

We show an example workflow in **Error! Reference source not found.**. In this workflow, the user first selects a patient from patients in the waiting area. Then the system displays a summary graph of the patient's weight over time. In the next step, a decision brick queries the age of the patient (as defined in the demographics record) and decides whether or not to collect height in addition to weight information.

More sophisticated flows can be incrementally built by adding bricks to the construction area and sequencing them. **Error! Reference source not found.** shows an extended version of the flow in **Error! Reference source not found.** where an additional branch from the age decision brick (yellow brick) can lead to recording of mid-upper arm circumference (MUAC) instead of height or weight depending on the patient's age. The flow ends with scheduling the patient's next appointment before sending the data to the storage engine.

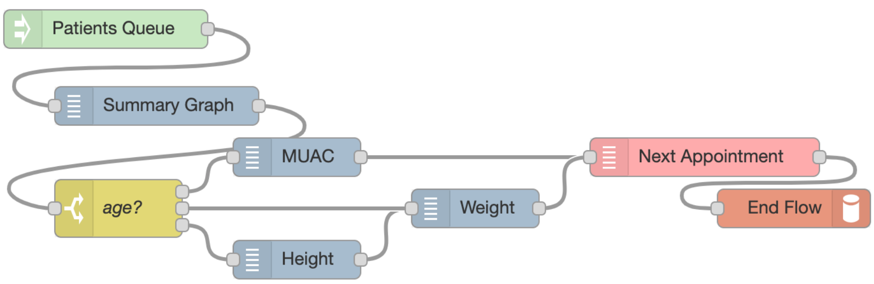

Figure 2. Closeup of the vitals flow showing additional branch to record mid-upper arm circumference (MUAC)

Subflows.

As workflows become more complex, they can become harder to understand. To remedy this, workflows can be broken into subflows. A subflow represents a flow, but is visually 'collapsed' into a single brick. Subflows act as placeholders and decrease the information density in the construction area.

Typically, subflows are used to logically group independent sections of larger flows to reduce visual complexity and to introduce reusable components. Most of the time a subflow brick has one input and one output. The runtime environment expands subflows as it steps through the larger flow. Figure 1 shows our ongoing example of a vitals flow with a subflow for collecting height, weight and MUAC measurements.

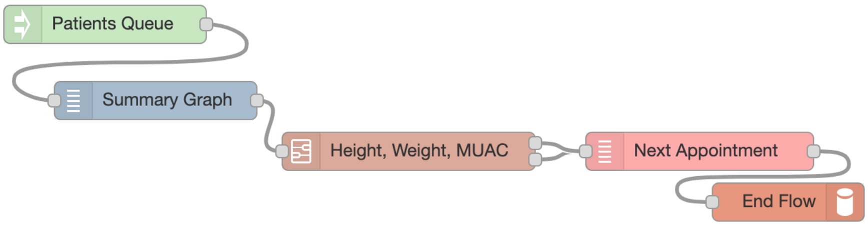

Figure 1: Vitals flow with Height, Weight, MUAC subflow

Calculated/derived values.

It is common in medical practice to calculate a value from existing clinical data e.g., calculating body mass index (BMI) using height and weight to diagnose obesity. Automatically calculating such values decreases assessment time and can increase both quality of care and adherence to clinical guidelines.

Calculations in the Care:Bricks design environment are implemented using a specific intermediate brick called a function brick. A function brick allows the designer to incorporate mathematical and/or logical statements in their flow. For example, BMI is defined as weight (kgs) divided by height (m) squared. As we have previously captured the height in cm in our example flow we multiply everything by 10,000. To implement this function, we write this piece of logic in a small JavaScript code block.

```
encounter.bmi =
 10000 * Number(encounter.Weight) /
 (Number(encounter.Height) * Number(encounter.Height));
```

Clinical Decision support.

In clinical practice, patient symptoms, signs and data are used to interpret the patient's state. For example, BMI derived from adult weight and height determine if a patient is obese or underweight. Most clinicians know that normal BMI is between 18.5 and 24.9 but don't necessarily memorize what constitutes a BMI for severe malnutrition or Class 3 obesity. As a digital job aid, we incorporate clinical thresholds in our flow and provide clinical decision support.

For example based on results of a calculated BMI, Care:Bricks branches into different care paths. We guide the clinical user to refer to the malnutrition unit if the normal BMI threshold is not reached and to the chronic care if the overweight BMI threshold is exceeded. This of course can be extended further. For example, for patients with mild cases of over- or under-weight providers could be given specific educational guidance on screen. This workflow can be seen in **Error! Reference source not found.**.

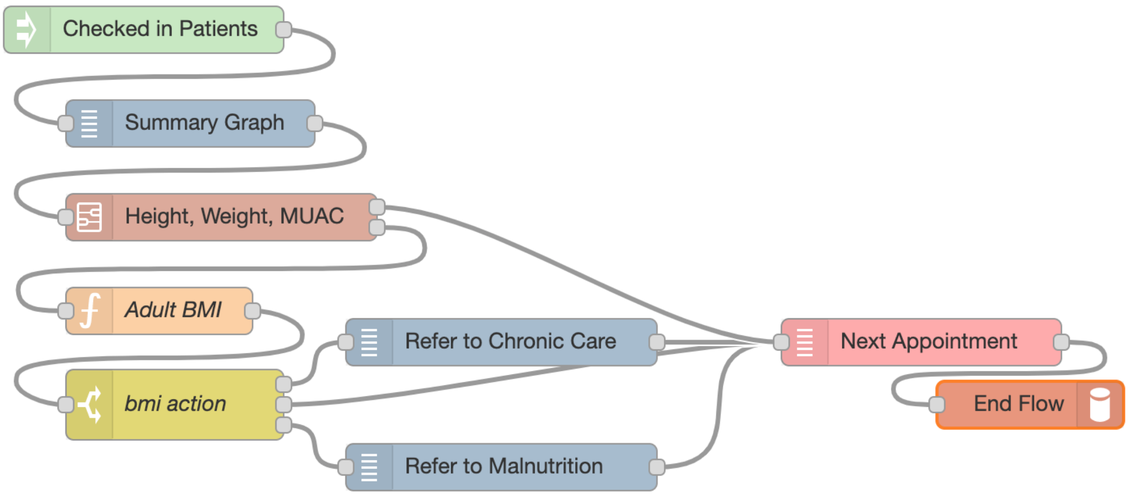

Figure 4. Clinical decision support

3.2 Runtime environment

The runtime environment takes the flows from the design environment and renders workflow screens in a web browser using the brick type to render one or more predefined screens. Care:Bricks includes a set of bricks and associated screens for most frequently used elements of EMRs. These bricks and associated screens can be used to develop workflows with no additional programming.

After a workflow is deployed to the runtime environment, it becomes immediately active (at least in simple deployment setups where the design and runtime environment are on the same system) and can be selected by the clinical user. As bricks have their own pre-defined user interfaces and for above vitals flow pre-defined bricks were used from the brick library, no additional programming is required. Once the user (or in some cases the runtime environment) selects and starts a certain workflow, the steps are executed from left to right. Not all steps require user interaction; some like the yellow age condition are implicitly evaluated by the runtime environment and not visible to the user. **Error! Reference source not found.** below represents the four steps of the simple vitals flow that require user interaction (Find Patient, Display Summary Graph, Enter Height, Enter Weight).

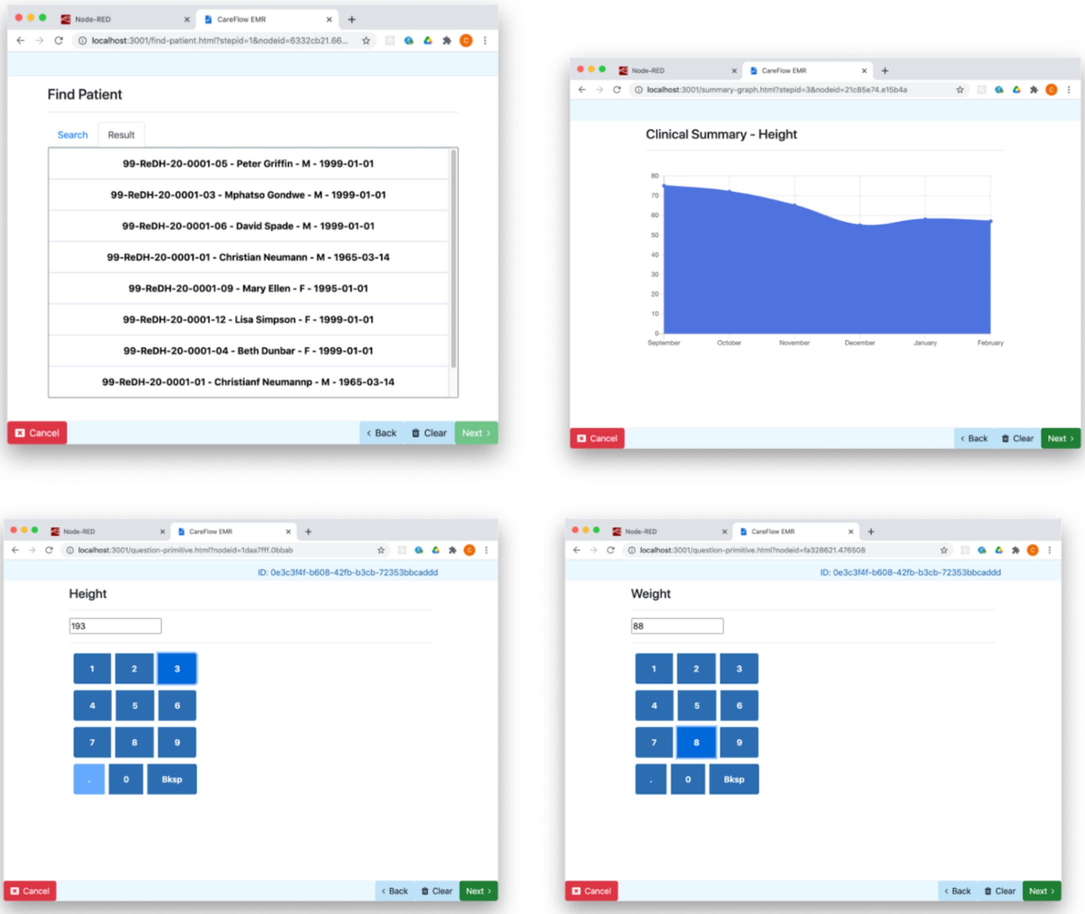

Figure 5. Sequence of screen for simple vitals flow in the runtime environment

3.3 Data Representation & Storage Engine

Following our LMIC-approach themes of process-centricity and low-cost, we implemented a simple storage engine for Care:Bricks using a generic interface to access patient data as datafiles, eschewing a formal relational or object database. Our conceptual model is a straight-forward mapping from the paper record; for the data storage engine (database), we have used a minimally invasive technology which directly supports the process-centric approach. Our logical implementation is a file in JSON format with a single directory for each patient and we utilize a standard filename convention that incorporates patient id and the type of record for each data unit of patients.

While the file storage is an atypical approach, it worked rather well. Even for a large facility (45,000 patients, 5.5 million encounters, 27 million observations) we simulated adequate performance for data entry and retrieval (excluding reporting): With 400 visits per day, spread across 10 different point-of-care locations within this facility, a new encounter will occur on average every ~7 seconds (8 clinic hours * 60 minutes per hour * 60 seconds per minute) / (400 visits * 10 stations). A Single board Computer like a Raspberry Pi 4 with a flash-based storage was able to process around three requests per second (simulating a mix of query and write operations).

Operating costs for storage are kept low. In our prototype implementation (with a rather verbose JSON structure), the size of a demographic patient record was typically less than 2 KB and for a complete visit averaged around 5 KB (spread across multiple encounters and excluding photos/scans/biometric information). The demographic records for 45000 patients resulted in 30 MB of raw data, while ~20 GB were needed for 5.5 million encounters.

Again, considering operational costs and associated skill acquisition overhead, standard operating system tools can be used for data backups (like regularly creating compressed archives of the patient data via cron, tar and gzip; and scp, rsync for remote backups).

3.4 Development environment

While we aim to provide a comprehensive solution for developing basic workflows, we also want the system to be extendable. Intentionally there is a gradual transition from an advanced EMR designer into someone extending the core environment. Similar to EMR Designers we assume as little product-specific skills as possible for the development. We favor a tool- and framework-agnostic solution over assuming a certain approach, even if additional tools or frameworks would provide some short-term benefits. The environment is kept as simple as possible with its modular approach of having minimal assumptions and providing maximum flexibility.

4 Discussion

Optimizing clinical care using digital systems requires that workflows are at the core of a system. Information collected is most beneficial to clinical decision-making at the point of care, and, when enhanced with clinical decision support, these digital systems can have far greater impact. Also, all systems change over time. Sometimes changes are minor and infrequent, sometimes extensive and occurring often. It is crucial that EMR changes can be done quickly, with minimal expense and by those who are closest to the work, ideally without needing to involve developers.

By transforming programming code into graphical flows, the EMR design becomes transparent. This approach enables EMR Designers with less IT/programming skills. Instead, the required skills set pivots towards non-technical clinical managers and monitoring & evaluation (M&E) staff, who potentially are already defining textual guidelines and data use in the clinical context. This removes the often-prevalent communication gap between clinical experts and ICT experts while shortening the development cycles. NodeRED [18] (an open source environment originally developed by IBM) was initially chosen for the design environment as it follows the core principles of flow-based programming for event-driven applications. But any generic flow editor could be adapted to work.

The field of software engineering has seen multiple attempts to raise the level of abstraction by providing higher-level programming environments. From Rapid Application Development environments (like Microsoft Visual Basic), Database-driven systems (such as Microsoft Access), fourth-generation programming languages and graphical notations for business process models like BPMN, up to the recent cloud-based Low-Code/No-Code development platforms (Airtable, Microsoft Power Automate). Some of these approaches found their niches but are not widely adopted.

In all these environments, good engineering practises such as versioning, collaboration in bigger teams and testing can be problematic. Additionally, advanced developers often find these environments (too) limiting as things need to be done within the pre-defined boundaries of the platform (‘my way or no way'). Beyond the psychological component for “real programmers” this has the real danger that investments in a specific platform might be lost once the platform vanishes or technology advances. In the world of open-source EMR systems, there is a strong emphasis on ‘traditional’ software development. While this makes these tools very flexible and adjustable to many different usage scenarios, it also puts a significant burden on the required skill sets for the developers. It is difficult to find and maintain qualified programmers across LMIC countries. Such a focus on development also increases the risk of talking more about code and technical problems instead of focussing on the business requirements.

Care:Bricks does not aim to be a fully-integrated and encapsulated/closed platform. We wanted our solution to be as modular as possible so that aspects of the system are not bound to a singular solution or framework. With this in mind, we created a clean separation between the workflow design environment and the runtime environment. In between sits the intentionally simple and open workflow model. By carefully separating different layers, any layer could be individually replaced with other technical solutions. For example, while we favor a particular kind of data storage, other mechanisms could also be implemented without impacting the other layers.

We have applied the same principles of lean design to the data storage layer. Commonly used generic persistence solutions can introduce significant overhead. Storing data points as observations in a typical relational database with a flexible Entity-Attribute-Value model can result in a scenario where the data for internal management and indexes is higher than the actual medical records. This not only has an impact on the required physical storage and memory consumption, but can also introduce additional performance bottlenecks for data access and reporting. Surprisingly there are only very few situations where data gets updated concurrently (in a point-of-care setting a patient can only be at one location at a time). And even in cases of concurrent edits, there are often no true conflicts as data typically gets voided and re-added. So the data storage predominately follows a write-once, rarely-update strategy; allowing to question the need for a full ACID-compliant database. Instead of imposing a traditional database just because it is the default choice, Care:Bricks keeps all data for patients in separate subdirectories and all visits plus the demographic record is kept in separate files in that directory. While there is some variation in the size of the data, a demographic record can often be stored with less than 1 KB, and the data per visit usually does not exceed 5 KB even for complex visits (excluding photos/scans/biometric information).

But regardless of this storage simplicity, depending on the number of patients, visits and file system performance, access to multiple patients at once, might be challenging. For these cases a ‘custom index’ for searchable data points (either in-memory or persisted on the filesystem) can be programmed to speed up retrieval time. This mechanism is also utilised for the ‘queue management’ of patients. However, if additional needs to the storage engine arise, Care:Bricks is open for more conventional persistence layers like CouchDB. The implementation of the ‘custom index’ is also the foundation for the ‘derived data representation’. It is a re-programmable, event-driven, on-the-fly transformation of data from the internal data representation into an external format like FHIR, ‘flat tables’ or transaction logs for synchronization.

Our solution directly addresses barriers to implementing EMRs in LMIC settings and has features that would maximize sustainability when donor funding is no longer available. Acquisition costs are reduced largely by eliminating the need for implementers with specialised software development skills, and through the use of low-cost hardware, possible due to the use of light-weight technologies. Disruptive effects on clinical care practices are addressed through our process-centric approach rather than data centric approach. Operating costs are reduced in several ways. Emphasis on lower cost hardware means that periodic replacement of equipment will be less expensive. Reliance on low-power hardware means lower operating costs in terms of consumption of electricity. The cost of electricity may seem inconsequential. However, in off-the-grid sites where systems rely on power to be generated, and potentially stored in battery backup systems, the cost of the power system can often exceed that of the computers themselves. Updates to the system to reflect changes in guidelines can be done quickly by existing staff, thereby eliminating the requirement for paid consultants. The simplification of rendering the workflows creates a sufficiently intuitive user interface for “computer-illiterates” with no mouse/keyboard skills.

5 Future work

While Care:Bricks currently focusses on the rapid definition and execution of workflows, we plan to include a data representation layer for HL7-FHIR as well as linkages to standard terminologies such as SNOMED-CT and ICD10. We also envision dedicated Datatype- and Concept-Editors to establish and enforce a ‘common language’ and an explicit data dictionary. Together with a Roles-based permission model for the Design environment these aspects could provide support for hierarchical national scale-ups.

6 Conclusion

Large strides have been made in the past two decades to get EMRs working in LMIC settings. However, there are still significant gaps that need to be addressed before these systems reach their full potential. Our aim with Care:Bricks is to help democratize EMR development to the point where they can be locally developed and maintained, getting us one step closer to a truly LMIC-First approach.

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Journal of Health Informatics in Africa

Adapting e-self-assessment from the private Sector to build the capacity of health supply chain staff in public health facilities: Lessons from implementation in Uganda

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1 Background

E-learning has become an integral part of institutions and transformed continuing education endeavors. Institutions have embraced this pedagogy as an alternative to the traditional educational systems, which lack the dynamic needs of learners. However, there is slow adoption of this new pedagogy by institutions and potential beneficiaries.

2 Objective

To develop and conduct proof of concept of an integrated self-assessment quality improvement approach at public and private not-for-profit health facilities to boost system-wide performance along the health supply chain.

3 Method

This article outlines the results of a proof of concept of an electronic supply chain self-assessment in public health facilities in Uganda. Four Referral Hospitals (Entebbe, Mbarara, Masaka, and Kiruddu) were selected based on their performance extremities. The study used a capacity building methodology where each facility self-assessed, and a subsequent quality improvement plan was auto-generated and ended with e-learning courses. Ten participants including pharmacy interns, stores assistants, and pharmacy technicians enrolled in the health supply chain e-learning course following the self-assessment scores. Data was analyzed using descriptive statistical techniques.

4 Results

In the facility self-assessment, Mbarara Masaka and Kiruddu scored over 70%, while Entebbe scored the least, 48%. The average self-assessment score was 75% similar to the external/independent supervision scores, with 9 out of the 13 modules having above 80% correlation to the independent assessment. On average, participants scored 90% in the online health supply chain final course evaluation. Participants expressed positive views about the self-assessment tool. Participants felt the self-assessment course was well structured, relevant to their work with clear objectives and well-organized content. However, participants felt the one week was inadequate given the course workload.

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5 Conclusion

The correlation between self-assessment and independent assessments is similar, with prompt e-learning being acceptable to health supply chain staff. The combination of self-assessment and e-learning can effectively improve the knowledge and competence of health supply chain staff; therefore, we recommend the scale-up of this method to more facilities. However, modifications and evaluation of the e-learning tool is required before any widespread implementation.

Journal of Health Informatics in Africa

Advancing Digital Health Capability of Healthcare Organizations—How to Navigate the Maze of Capability Model-Based Tools?

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Keywords (MeSH): Public Health Informatics (D040442)**,** Capacity Building (D057191)**,** Maturity Model (no MeSH)**,** Digital Health (no MeSH)**,** Global Health (D014943)**,** Digital Technology (D000082222)

1 Background

The ability of a health system to use health information for decision making depends on the capacity of its people, processes, systems, and organizations. Digital health has emerged as an integral foundation of a robust health system and is transforming processes, systems, people, and organizational capabilities around the world.[WHO 2020] Advancing the digital health maturity of healthcare organizations is a top priority of national governments; international organizations, such as the World Health Organization (WHO), International Telecommunications Union, and the World Bank; donors, such as the United States Agency for International Development (USAID), Centers for Disease Control and Prevention, and United States President's Emergency Plan for AIDS Relief; and private sector actors, such as the Microsoft Corporation, Philips, IBM, and others. Identifying digital health strengths and weaknesses is critical to inform national strategic planning of a healthcare organization. It is likewise essential for donors to understand—at technical and granular levels—where countries are on the digital health maturity continuum, and to monitor progress of investments and program outcomes over time.

Over the past five years, the global digital health community has supported the development and implementation of several maturity model-based assessment tools.[MEASURE Evaluation 2019] The USAID-funded MEASURE Evaluation project developed the Health Information System Stages of Continuous Improvement tool (SOCI) and the Health Information System (HIS) Interoperability Maturity Toolkit (IMM). WHO developed the Survey, Count, Optimize, Review, Enable (SCORE) technical package and is working to prepare the Dynamic Digital Health Maturity Models. The Pan American Health Organization developed the Information Systems for Health Toolkit (IS4H). Last, the Kati Collective Inc. created the Early-Stage Digital Health Investment Tool (EDIT), and Health Enabled developed the Global Digital Health Index (GDHI). These maturity models focus on people, processes, technology, and organizational capabilities, and help users understand the current state of things and determine a future goal. Low maturity levels indicate an opportunity for investment and leapfrogging, whereas higher maturity levels illustrate a higher probability of success for disruptive interventions.

The six tools listed above serve a specific purpose but also overlap in terms of their focus on digital health systems, people, processes, and organizational capabilities. Although the overlap and nuances are obvious to the tool developers, digital health planners, implementers, and practitioners are confused by the deluge of maturity-model based tools. The Digital Health Capability Model Navigator, funded by the

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Digital Square project of USAID and led by the Carolina Population Center of the University of North Carolina at Chapel Hill, USA, is a resource that enables users to navigate the maze of maturity model-based tools.

The purpose of our panel is to introduce and share information on the various capability model-based tools and to showcase the value of a collaborative approach to develop the Navigator. The panel will present a Microsoft Excel-based decision-support workbook that allows digital health planners, implementers, and practitioners to identify and use appropriate maturity model-based tools from the pool of six tools and identify which indicators from past assessments should be reviewed before conducting a new assessment. The objective of this panel is directly linked with the maturity model sub-theme of the conference. The panel presentations will demonstrate how advanced capabilities can enable "Leveraging Digital Health Interventions to Enhance Prevention, Response and Control of Public Health Emergencies in Low and Middle-Income Countries." The panel discussion will encourage dialogue among the participants to share and discuss digital health maturity initiatives. The panel will highlight digital health stakeholders (national and international) who are applying and/or developing maturity model-based tools to strengthen digital health capabilities of national governments and digital health organizations. The panel session will offer an opportunity for the participants to learn about the Digital Health Maturity Navigator and how to use it. The discussion will create an enabling environment for open and candid conversation among the participants and with the panelists.

The panel presentations and discussions will be moderated by Paul Mbaka, Ministry of Health, The Republic of Uganda. Uganda has been at the forefront of digital transformation and has applied several of the maturity models to assess and improve HIS strategy, interoperability, digital health policy, and infrastructure. Adele Waugaman of USAID will present and discuss how digital health maturity is essential for health systems strengthening and to address challenges posed by a pandemic, such as COVID-19. Gabriel Catan will share how the World Bank is leveraging maturity model-based tools to guide its digital health efforts at the country level. Swaroop Jayaprakash of IBM/USAID GHSC-PSM will discuss how supply chain information system maturity models are critical for enhancing supply chain capabilities of the health system. Last, Manish Kumar from the University of North Carolina at Chapel Hill will present and demonstrate how to select appropriate maturity models from the pool of six tools and whether it is possible to use the findings from past maturity model assessments. Each panel presentation is briefly described below.

Presentation 1: Digital Health and COVID-19 Response – Adele Waugaman

As Senior Digital Health Coordinator– COVID-19 Response at USAID, Adele advises on the Agency's COVID-19 response, informed by the priorities of the USAID Vision for Action in Digital Health, the Agency's first dedicated policy guidance on investments in digital technologies that supports country-based health programs. The first of four priorities in the Digital Health Vision is to build country capacity for the effective planning for, and management and use of digital health systems. Adele will describe the importance of aligned and well-supported health information system assessment tools—for countries to plan their health sector digitalization journeys, and for funders and technical partners who are supporting them along that journey—in both the immediate COVID-19 response and for ongoing health system strengthening.

Presentation 2: Digital Health Maturity – Gabriel Catan

The advancement of technology and the exponential growth of data are providing the opportunity to low-income countries and lower-middle-income countries to leapfrog and improve quality of care, decision making, and the efficient use of resources, while reducing costs and the burden of diseases. Recognizing the promise and potential of digital systems, technologies, and data to transform primary healthcare and solve pernicious healthcare challenges in countries, digital health maturity assessments intend to be an input to plan and prioritize how a country's future health system would look. There are various digital health assessments tools created by different donors and organizations that help countries and organizations assess and evaluate their digital maturity, from a macro perspective to a more specific one, such as data, artificial intelligence, and interoperability. This presentation will discuss a hybrid approach that intends to increase collaboration between the different digital health assessments tools by leveraging existing indicators.

Presentation 3: Supply Chain Information System Maturity Model – Swaroop Jayaprakash, IBM/USAID GHSC-PSM

Global health supply chains are growing in complexity as they respond to changing patterns of commodity flows and demand for more accurate information in an increasingly digitized world. It is essential that information systems—which form the backbone of today's supply chains—mature to manage the growing complexity. Weak information systems can hinder effective responses to supply chain exceptions, especially to global supply chain events, including public health emergencies. A holistic approach is essential in assessing and identifying improvement opportunities across overall supply chain information system (SCIS) functionalities in a coordinated way. The USAID GHSC-PSM project has developed one such approach—the Supply Chain Information System Maturity Model (SCISMM)—to help countries analyze their current supply chain systems holistically and plan their investments in supply chain information systems accordingly. The SCISMM is a guiding tool to aid supply chain actors, including governments, donors, and implementing partners, in planning and strategizing around future SCIS investments to enhance the functionality of public health supply chain operations. The model can be used to evaluate current capabilities or to target priority areas for improvement or development, as in the case of its application in Guinea, Nepal, Pakistan, and Rwanda. This presentation will introduce the SCISMM to participants and share learning experiences from using this model in countries.

Presentation 4: Digital Health Capability Models Navigator – Manish Kumar

The Digital Health Capability Models Navigator ("the Navigator) supports digital health stakeholders to identify the tool(s) that are most appropriate to their assessment goal. For example, digital health planners or managers in a ministry of health can use the Navigator to identify the best-for-fit assessment tool and determine how findings from past maturity model assessments can be leveraged, as applicable. For funders of digital health interventions, the Navigator offers an opportunity for more effective targeting of resources by recommending the most appropriate tool and diagnostic tool to inform investments, along with guidance on how to draw from the results of previous assessments conducted in the same setting. The Navigator describes the value of using a maturity model-based tool and offers the opportunity to determine a best-for-fit tool. The Navigator provides guidance on how to align tools with assessment goals and how to use tools in combination, by identifying areas of overlap with tools that have been used previously in the same setting. The Navigator is specifically designed for those with some experience and knowledge in digital health and/or health information systems. However, a guidebook that is used with the Excel-based workbook, offers additional background information that those who are newer to the digital health scene should review thoroughly before using the Excel-based tool.

Panel Discussion

Digital health maturity models establish a common framework to assess, monitor, and improve digital health processes, workforce capacity, systems, and institutional capabilities. Application of a common framework allows digital health stakeholders to identify standard benchmarks and desired capabilities, promote collaboration, and increase coordinated efforts and investments from national governments, international digital health community, and other development actors supporting adoption and use of digital technologies.

The panel discussion will encourage dialogue among the participants to share and discuss digital health maturity initiatives. The panel will highlight digital health stakeholders (national and international) who are applying and/or developing maturity model-based tools to strengthen digital health capabilities of national governments and digital health organizations. The panel session will offer an opportunity to the participants to learn about the Digital Health Maturity Navigator and how to use it. Furthermore, the discussion will create an enabling environment for open and candidate conversation among the participants and with the panelists.

Learning Objectives:

By the end of the session, participants will:

- Identify and discuss digital health maturity model initiatives.
- Learn how global and national-level actors are applying maturity model-based tools.
- Understand the purpose and scope of the Digital Health Maturity Capability Models Navigator.
- Discuss and provide feedback on how the Navigator addresses some of the challenges associated with the availability of multiple maturity model-based tools at the country level.

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Journal of Health Informatics in Africa

Preparing Health Supply Chains to Respond to Emergencies by Bridging the Silos of Information Systems

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1 Background

Global health supply chains are growing in complexity as they respond to changing patterns of commodity flows and demands for more accurate information in an increasingly digitized world. Recent global supply chain events surrounding the COVID-19 pandemic have highlighted the importance of public health supply chains while exposing their vulnerabilities. It is essential that information systems, which form the backbone of today's supply chains, mature to manage the growing complexity, and respond better to changing dynamics. As physical commodities move through supply chains, information systems enable the flow of commodity data, ensuring that medicines are moving from manufacturer to national or regional warehouses to health facilities and, finally, to patients. Weak information systems can hinder effective response to supply chain exceptions, especially to global events, including public health emergencies.

Traditional approaches to improving supply chain information systems (SCIS) tend to have a narrow scope. They focus on one health area, such as HIV or a specific operational component such as warehousing. A holistic approach, on the other hand, enables coordinated, informed decision making by government leaders, donors and partners to improve overall SCIS. Such a holistic approach contributes to establishing essential foundational building blocks such as data standardization and interoperability. The USAID Global Health Supply Chain Program-Procurement and Supply Management (GHSC-PSM) project has developed one such approach, the Supply Chain Information System Maturity Model (SCISMM) to help countries analyze their supply chain systems holistically and plan investments in SCIS accordingly.

While the SCISMM has been developed in the context of public health supply chains, it was designed with core supply chain industry best practice and principles in mind, including the Supply Chain Operations Reference (SCOR) Model and the American Productivity & Quality Center (APQC) Framework. SCISMM can be used to assess holistically the strengths and weaknesses of the SCIS that countries use. Based on the assessment, recommendations for improvement will be defined based on a country's goals, priorities and constraints. These recommendations can be used to develop implementation roadmaps, which in turn can inform the development of national digital supply chain strategic plans to ensure planned initiatives receive adequate investments in time and resources. This will help steer investment into the most needed areas, which is even more critical for the often resource-constrained public health sector.

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SCISMM assessments in countries have helped identify important SCIS gaps, including the need to establish foundational building blocks such as standardized product master data management. As a result, countries such as Rwanda have focused efforts on implementing a National Product Catalogs (NPC) based on global standards as a critical step towards achieving commodity traceability and patient safety.

This panel will share experiences from countries that used SCISMM to adopt a holistic approach to SCIS investments. The panel will highlight the importance of essential SCIS building blocks such as NPCs that promote data standardization. The panelists will also be sharing learnings from their country's journey towards product data standardization. The panel's purpose is directly linked with the digital health initiatives and implementations and the maturity models sub-themes of the conference.

The panel presentations and discussions will be moderated by Mr. Swaroop Jayaprakash. His presentation will provide context around the use of maturity models in holistically improving supply chain systems and the importance of foundational SCIS capabilities such as product master data management. Dr. Ramy Guirguis from USAID/GHSI will present USAID's digital health vision and how it can be implemented in the supply chains domain and share experiences from key digital implementation initiatives that have leveraged SCISMM. Mr. Godfrey Kadewele from the Malawi Ministry of Health will share Malawi's experience of implementing NPC and using SCISMM assessments to prioritize SCIS investments. Ms. Edith Munyana from the Rwanda Ministry of Health will share key initiatives helping the progress of Rwanda's Digital Transformation. Finally, Dr. Rana Muhammad Safdar and Dr. Muhammad Tariq will present on Pakistan's use of a holistic approach to developing a comprehensive national information technology (IT) strategy. Each of the panel presentations are briefly described below.

Presentation 1: Importance of Holistic Approach and Standardization to SCIS - Swaroop Jayaprakash

This presentation focuses on the importance of a holistic approach to enhancing SCIS. It will include details of the SCISMM, including its structure, levels of maturity and how countries and organizations can use it to assess their SCIS capabilities. Swaroop Jayaprakash will also emphasize the importance of foundational SCIS capabilities such as master data management and introduce the NPC initiative that is helping countries adopt standardization and interoperability. This presentation aims to set the context for this panel to discuss the benefits of using holistic assessments such as SCISMM and the importance of foundational SCIS capabilities.

Presentation 2: A Digital Health Vision for Supply Chains - Dr. Ramy Guirguis

As senior information technology advisor at USAID/GHSI, Dr. Ramy Guirguis Dr. Guirguis is leading the digital supply chain technical priority area for the USAID Commodity Security and Logistics Division and advises various countries and USAID missions on the digitization of their national-level public health supply chain systems. Through this presentation, Dr. Guirguis will share USAID's digital health vision, and its four priorities This presentation will highlight key digital intervention initiatives including use of information system maturity models and NPC as a foundation for implementing the digital health vision in the supply chain domain helping promote two of the four priorities.

Presentation 3: Rwanda's Digital Transformation Journey – Ms. Edith Munyana

Rwanda has made many gains in information communications technology infrastructures over the past few years. These include achievements in the automation of systems that are operational at many levels of Rwanda's public health supply chain and incorporated an innovative mix of paper-based and technological solutions. Rwanda continues to invest in digitizing its health infrastructure and focusing on its public health supply chain, which is essential in ensuring availability of medicines for its citizens. This presentation will share Rwanda's progress in digital supply chain transformation and key initiatives that have aided that journey. Ms. Edith Munyana will highlight how use of maturity models such as SCISMM have helped focus on progressive initiatives such as NPC and how those initiatives will benefit the public health supply chain. This presentation will also share the associated people, process and policy activities that are essential, along with technology-related activities, in preparing supply chains to perform efficiently and respond to health emergencies.

Presentation 4: Integrated and Collaborative Digital Supply Chain for Malawi – Mr. Godfrey Kadewele

Malawi has made strides in strengthening data management and improving data quality of public health supply chain processes. The country continues to make efforts to promote end-to-end data visibility and support availability of medicines. Mr. Godfrey Kadewele will present on the initiatives Malawi is implementing to achieve an integrated digital supply chain that contributes to increased collaboration across its national supply chain as well as with global organizations. He will share Malawi's experience utilizing SCISMM to review the existing SCIS and how it is helping develop a comprehensive strategy for an integrated digital supply chain journey. He will also share details of Malawi's NPC implementation and his vision for its critical use in health emergencies.

Presentation 5: Holistic Approach to Implement Interoperable and Robust Healthcare Systems for Pakistan – Dr. Rana Muhammad Safdar and Dr. Muhammad Tariq

Real-time information is one of the key pillars of an efficient and responsive health system. IT plays a pivotal role through automation of critical functions of healthcare delivery systems to achieve end-to-end data visibility. Linking preventive and curative health paradigms through technology has resulted in better health and social outcomes for communities in Pakistan. Dr. Rana Muhammad Safdar and Dr. Muhammad Tariq will present on how Pakistan has adopted a holistic approach in reviewing existing health and SCIS. They will present on the progress Pakistan is making to develop a comprehensive national IT policy, strategic framework and enterprise architecture. Through this presentation they will share their experiences in using SCISMM and how it has contributed in their effort to develop comprehensive IT strategies.

Panel Discussion

The panel discussion will encourage dialogue among the participants to share and discuss digital supply chain initiatives that can enable countries and organizations to respond better to public health emergencies. The panel will highlight digital health stakeholders (national and international) who are leveraging maturity models to identify SCIS improvement areas in a holistic fashion and are implementing foundational initiatives around standardization as a key step towards supply chain agility and efficiency. Participants will have the opportunity to learn about the SCISMM tool and the NPC initiative. They will also be able to learn from country experiences on digital implementations and ask questions. Furthermore, the discussion will create an enabling environment for open and candid conversation among the participants and with the panelists.

Learning Objectives:

By the end of the session, participants will learn about:

- The SCISMM and how global and national-level actors are applying SCISMM to prioritize SCIS investments holistically
- The importance of data standardization and how it can help supply chains perform better
- The NPC initiative and experiences from countries
- Country digital supply chain implementation experiences and have questions answered

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Institutionalizing State Health Workforce Registry for Improved Human Resources for Health Efficiency

Ezinne Peters, Alozie Ananaba, Nkata Chuku, Abbas Gbolahan, Agbonkhese Oaiya, Bambi Tinuoye, Ífeoma Kalu-Igwe, Precious Eze

1 Background and Purpose

Nigeria is facing a health workforce crisis characterized by an inadequate number and types of health care workers, inequitable distribution as well as gaps in Human Resources for Health (HRH) data. These challenges negatively impact access to health care services, undermining the achievement of Universal Health Coverage (UHC) goals. In Oyo, a state in southwest Nigeria, there is a dearth in the availability of HRH information. When available, the information is not standardized making it ineffective for managing the health workforce. To address this challenge, Oyo state with support of the Global Fund, developed, and is implementing a workforce digitalization strategy. This strategy involves the development of a HRH data repository that serves as a reliable basis for a redistribution model for the health workforce. This data and the related redistribution model will contribute to improving the effectiveness of the existing health workforce.

2 Methods

A needs assessment for institutionalizing an HRH registry was conducted as a first step. This assessment involved consultations with relevant stakeholders involved in the management of health workforce information in Oyo state. They were drawn from the State Ministry of Health (SMoH), Hospital Management Board (HMB) and State Primary Health Care Board(SPHCB). Subsequently, a governance structure – the Technical Working Group (TWG) - was developed. This group with technical assistance from Health Systems Consult Limited (HSCL) was responsible for providing oversight on the adoption of data elements (Minimum Data Set - MDS), development of an electronic health worker data collection tool, validation of the health workforce data collected. HSCL with support of the TWG designed and customized the electronic web-based registry, using Opensource iHRIS Manager application. Oyo State Health Workforce Registry (SHWR) platform was deployed online in Q3 2020. Existing health workforce information was cleaned, verified, and imported from government-run health institutions across the three levels of care: primary, secondary, and tertiary. Importation of data to the SHWR platform was conducted in a phased approach due to the unavailability of complete data within the project timeline and the peculiarity of the year 2020 in the light of the COVID-19 pandemic. To ensure sustainability, the state's capacity to use the platform was built on the use of the platform and the project was transitioned to the state who will further update the platform to completion. As at the end of the project (November 2020), the level of completeness of data on the platform was 69%.

3 Results

Primary analytics on the platform showed that of the total number of health workers in the state registry; 69% are female, with about 81% of the workforce predominantly in their productive age (25 – 55years). 29% are highly skilled comprising of doctors, nurses, and midwives, while all others which include lower-skilled staff such as CHEWs, JCHEWs, Health Assistants, Health Attendants as well as administrative level staff; Executive Officers, Drivers, Security staff make up the remaining 71%.

Conclusions:

Prior to the institutionalization of the SHWR platform, there was no system in place in the state to manage HRH data neither was there any unified database containing a state-wide HRH information. The established State Health Workforce Registry highlights a shortage in the skilled health worker density recommended to attain high coverage of essential health care services. The results showed the workforce composition and distribution results from the Registry showed a disparity in skill mix as the state has fewer higher skilled staff concentrated in urban regions and this could impact the quality of care provided. Key state actors, particularly the SMoH, have now utilized the SHWR workforce outputs to develop an HRH workload redistribution model, utilizing the Workload Indicators of Staffing Need (WISN) methodology [5] to maximize productivity and performance of the existing health workforce. Stakeholders reported that the SHWR platform has made management of HRH information seamless from capturing data to analytics, however the unavailability of funds to maintain the subscription for the platform has posed barrier to continued use of the system.

Keywords: Universal Health Coverage, Human Resources for Health, Human Resources for Health Information System, Health Workforce Registry, Workload Indicator of Staffing Need

[5] The components for HRH estimation such as the available work time, workload components including state prioritized health services, service statistics from the DHIS2, activity standards were determined through a mix of benchmarking standards from literature and consultative stakeholder workshop by the state governance structures expert group and technical task force

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A Maturity Model-based Practical Tool to guide the development of HIV data use roadmap in Ethiopia

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Keywords: Maturity model, HIV, Data use, Data quality, Benchmarking, Reference Standards, Ethiopia

1 Introduction

Ethiopian Federal Ministry of Health (FMOH) has implemented various initiatives to improve the quality and use of health-related data produced at all levels of the health care system. The FMOH has developed the Health Sector Transformation Plan (HSTP) since 2015 that focuses on addressing quality and equitable distribution of health service delivery for all. One of the five transformation agendas in the second phase of HSTP (2020/21-2024/25) is the "Information Revolution". The Information Revolution is not only about changing the techniques of data and information management; it is also about bringing fundamental cultural and attitudinal change regarding perceived value and practical use of information [1].

Currently, the aggregate health related reporting is done using the National Health Management Information System (HMIS) that includes monthly health service and disease reporting, quarterly and annual health service reporting. There are reporting forms at all levels which are digitized primarily using District Health Information Software-2 (DHIS2), the major digitization platform of the health sector. FMOH has effectively customized and scaled-up DHIS2 to ease the management of the HMIS since 2017. Currently, DHIS2 is implemented in more than 95% of the public health institutions. The data analysis, summarization, visualization and progress tracking will be augmented through the development and use of digital tools. Development and use of custom based dashboards for each level will support the decision-making process. HMIS is used by health posts, health centers, hospitals and health administrative units depending on the indicators they are expected to report on [2].

Bringing cultural transformation in data use is the most challenging part of the Information Revolution agenda in the Ethiopia's Health Sector Transformation Plan. Cultural transformation requires addressing barriers that are linked to technical, organizational, and behavioral factors. The decision-making and problem-solving behavior of data users can heavily influence the ultimate use of data for service delivery improvements. Even though some improvements have been observed with regards to data-based decision making using the HMIS routine reports by different health programs in the health care system, there is still a need for concerted efforts in terms of institutionalizing and standardizing data use culture at national, regional, sub-regional and health facility levels.

An assessment of an organization's analytics maturity is paramount to understand the multi-dimensional aspects of data use including the people, processes, technology and governance. The Health Information Systems (HIS) Stages of Continuous Improvement (SOCI), a maturity model assessment framework developed by MEASURE Evaluation has been helpful in identifying areas where systems can improve their data use and enabling countries to reach their information use goals. The maturity assessment framework is aligned with the program and quality of care improvement goals [3]. In this case study, we describe the process of deriving a practical assessment tool from the maturity model framework focusing on health data use and describe how the components will be used to design the data use roadmap. The actual maturity model assessment has not yet been performed.

2 Materials and methods:

CDC Ethiopia has been working closely with Addis Ababa City Administration Health Bureau (AACAHB) in HIV Program support with the associated monitoring and evaluation. AACAHB receives aggregate routine reports from public and private health facilities in the city. AACAHB is planning to establish need based and standardized data analytics capacity on the HIV related aggregate data (HMIS). HIS SOCI Toolkit has been used in different settings in assessing HIS whereby the result is used to strengthen the health system. Health Information Systems growth occurs in a continuous and non-linear manner, and the use of Maturity Model is found to be important to assess the current status and devise plan based on evidence. The tool measures the status and goals of an HIS, identifies gaps, and supports the development of roadmaps. The roadmap is meant to improve HIS capabilities related to processes, people, and systems and ultimately enhancing health program performance and population health. The maturity of HIS is evaluated using defined metrics which helps in describing the progress of each component of the HIS and data use over time [3].

Since January 2021, ongoing discussions has been made with AACAHB HIV Program, and Monitoring and Evaluation Team to understand the existing data use practice at the Health Bureau, the infrastructure, Human Resource capacity and data use priorities. The stakeholders provided structured inputs that described data use and analytics requirements, existing systems and practices, and the challenges associated with data use at the Health Bureau. We reviewed each domain in the HIS SOCI Toolkit and selected HIS data quality and use domain being relevant to this project. Both data quality assurance and data use HIS components were included that comprise of two and seven sub-components respectively. The generic scoring is adopted from the Toolkit to allow comparison with experiences elsewhere: Emerging/Ad Hoc (1); Repeatable (2); Defined (3); Managed (4); Optimized (5). The definitions of scoring for each sub-component was reviewed and adapted in alignment with the information we had from partner discussions and the guidance in the national strategic plan regarding the information revolution agenda. Understanding the health care system, the health information system, health workers perspective and the strategic guidance were helpful in adapting the maturity model and the assessment tool which will be used to develop a roadmap for data use improvement as per AACAHB priorities and the strategic plan.

The resulting scores, as determined by individual assessments and group consensus, will identify the current status of the data use sub-components and present these results alongside the identified goals for the data use. The measurement scale (1-5) can be used to identify where gaps between current and desired status exist and to develop concrete steps to address those gaps and measure maturity progress. The maturity assessment will be conducted at AACAHB that will provide information on the current status of data use, and the desired state following the six-months and one-year data use support.

3 Results:

The structured inputs from the stakeholders guided the identification of components and subcomponents which were aligned with many of the components and subcomponents of the HIS SOCI toolkit. The HIS SOCI tool was adapted to align with the stakeholder data use requirements. The adapted Data Maturity Model components and the major changes incorporated in the model is shown in the table below.

Table 1. HIS Core Domain, Components, Sub-components and the major adaptations in the data use maturity model in Ethiopia

HIS Core Domain	HIS Components	HIS Sub-components	Description of the major adaptations made in the maturity model
HIS data quality and use	Data Quality	1. Data quality assurance and quality control	Amended as per the existing data quality and feedback mechanism at FMOH and AACAHB
		2. Data management	National DHIS2 System considered in the model.
	Data Use	1. Data use standard	Data use standard in alignment with DHIS2, Performance Monitoring Team, and Health System Integration as per the FMOH hierarchy
		2. Information/data availability	Considered DHIS2 data systems or data storage mechanism; FMOH Data sharing policy considered in the model.
		3. Data analytic competencies	The stakeholder discussion guided relevant team for competency. Mix of HR including health managers, health workers and data managers included in the model.
		4. Reporting and analytics features	Currently existing analytics mechanisms considered as a baseline.
		5. Decision support (clinical or program)	The local need of program and clinical team in the strategic document and stakeholder discussion considered as a factor for the scoring.
		6. Systems/ Technology	Available resource at AACAHB taken into consideration while developing the model.
		7. Data Management Personnel	The model was developed considering available personnel plan and career structure at AACAHB.

4 Discussion

There has been some experience in designing and implementing data analytics at national and regional levels merely focusing on the analytics system component without considering the people and process aspects. It is very important that such data use interventions consider a comprehensive approach since deploying systems needs to be complemented by conducive environment to exercise the platform and use it for the intended purposes. Defining appropriate and objective methodologies to assess data use maturity level can be challenging. Global models are generic and not always context specific which needs understanding of the local setting in terms of strategy, health care system, health workers need, infrastructure, personnel structure and current data use practice in order that the generic material could be translated into practical tools. Using existing HIS SOCI Toolkit, we derived a practical tool for assessing HIV data use maturity and propose field-testing this in AACAHB to validate and routinize this methodology subsequently. We hope that this generic tool can be used for health programs other than HIV and in other countries with similar health system setting. This will support realizing data driven HIV epidemic control while promoting Health Sector Transformation

Statement on conflicts of interest

The authors declare that there is no known conflict of interest.

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University of Nairobi Mobile Application Rada

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1 Background and Purpose

According to the 2019 Census, Kenya has a population of 47.5 Million out of which 7.9 million (16.7%) are young people aged 15-24 years [(1)]. Most university students are in this age category with majority being aged between 17-24 years. Our national data according to the Kenya HIV Estimates report, indicates that 184,718 (2.3%) young people are currently living with HIV with 17,700 new infections annually [(2)]. Studies done in universities demonstrate the need to continuously sensitize students on Sexually Transmitted Infections (STIs), contraception and positive social behavior. Recently, a study was conducted on a sample of 1000 university students where they reported that 1:2 and 1:4 female and male students respectively had been sexually harassed to some extent while in campus[3]. This was part of the information that RADA application was founded on to help young people in institutions of higher learning to access health information with ease.

2 Problem statement

Young people in Kenya are faced with several challenges in health, career growth, and other personal issues that still remain un known to public. Covid-19 pandemic has brought up increased challenges on mental health, substance abuse and Sexual and Gender based violence to the young people. University students have been looking for ways to communicate with ease and get access to relevant information anonymously.

3 Broad Objective

To create an enabling environment at the institutions of higher learning with holistic dissemination of education towards graduating professionals who are ready to actively contribute to economic development.

4 Methodology

Under the leadership of UNESCO, the University of Nairobi Health Mobile application- RADA –UoN has been up graded to accommodate the feedback from the previous users. This time, the students were drawn from the various universities largely from where its dissemination was done, but also including some students from other institutions consisting of Pwani, Kenyatta, South Eastern Kenya, Masinde Murilo, St Pauls and Kabarak Universities, and Kiambu Institute of Science and Technology. The activities of the students were coordinated by the Centre for HIV Prevention and Research (CHIVPR) virtually during the Covid-19 lock down and guided by a UNSECO IT Consultant, and Sexual and Reproductive Health Rights Alliance facilitating internet bundles needed by the students to engage virtually. The University of Nairobi

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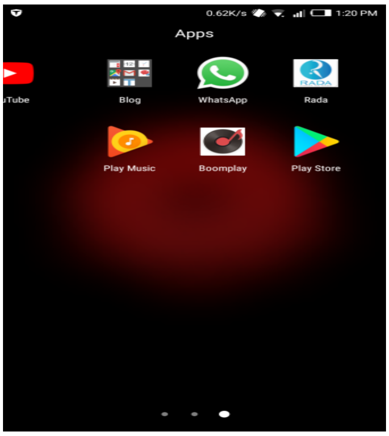
Dean of students and career offices worked closely with the RADA team, and Prof W. Kamau the chair of mentorship team contributed to mentorship information and the justice component. She also represents the mentorship program in the senate.

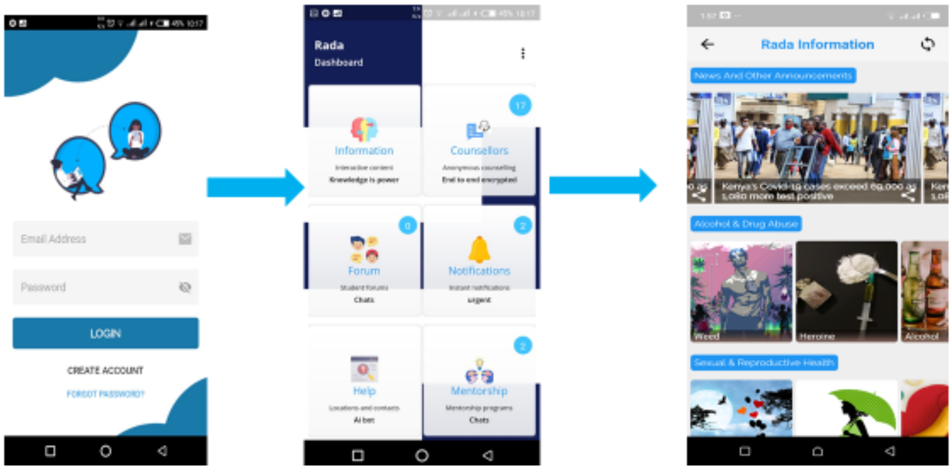
Below are some figures in the updated version;

Figure 1. Appearance on android phone Figure 2: The appearance once you tap rada Icon



Updated version:

Login process & Features

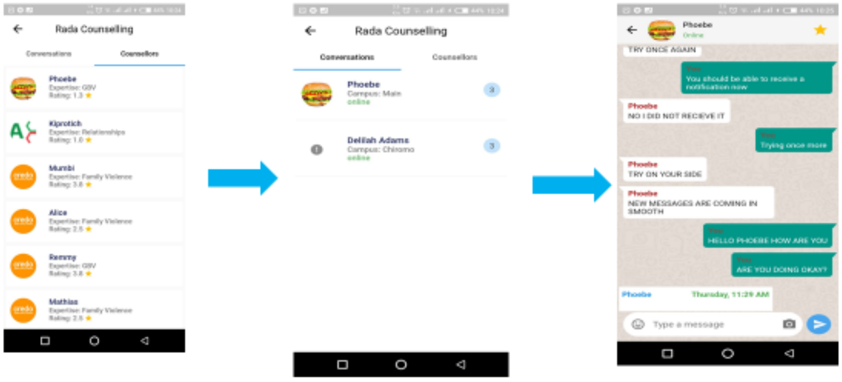


The students are supposed to enter an email and the University enrolment number for validation before getting to the application to get information and others services.

part of Information on the application

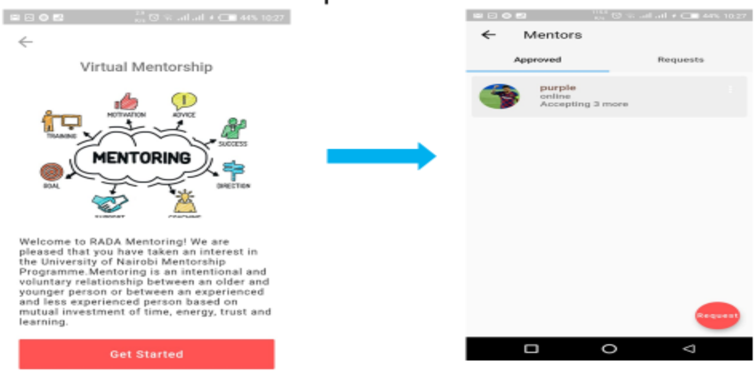
Depending on the information sort, the student clicks on the icons and it opens

Demonstration on Counselling Services



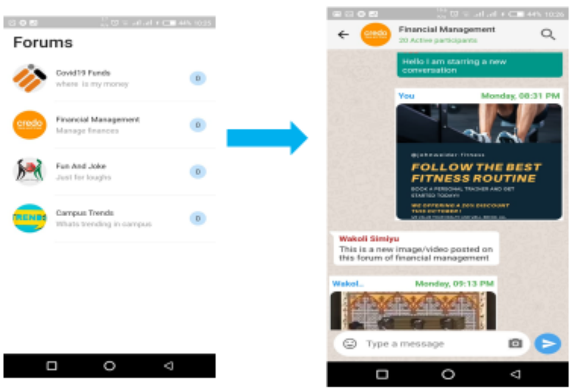
Counselling services are free for the University students. The purpose of validation is for students to get these services freely.

Virtual mentorship



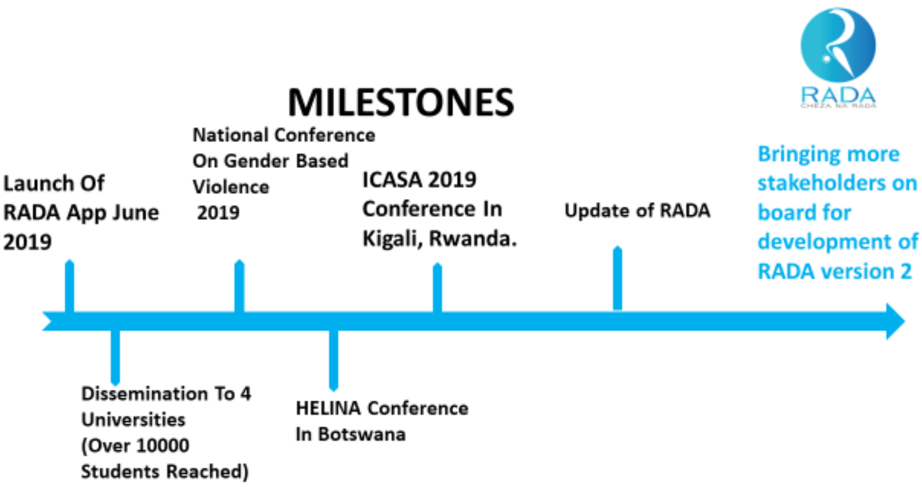
Virtual mentorship helps students get information on career growth, academic performance, financial management among other services of interest to students that will benefit their personal growth. Staff members and older students provide the services

Students forums



Many students prefer exchanging ideas among themselves and discussing current affairs in campus or in the nation.

These are services that students would want to seek including justice for those that are violated with gender based violence, contacts to call if in need, and to talk to the bot if one does not want to read.



5 Results

The students and partners continue to explore better ways of promoting Rada application with an aim of increasing access to relevant information to all University students while in campus including health and other aspects of personal growth. After the launch, the application was disseminated in all UoN campuses and four more Universities which included Kenyatta, Pwani, South Eastern Kenya, and Masinde Murilo Universities. The process enabled the team to reach 5782 individual students where 1000+ downloaded and continued interacting with the Application on various matters. To date, presentations of the App have been made at national and international conferences and print to and electronic media to disseminate it.

6 Discussion

The excitement of anonymous way of youth willing to get help was evident. After the launch several groups of students from different universities expressed interest in adopting the same to their colleges. This includes students from Kenyatta University, Daystar University, Jomo Kenyatta University of Science and Technology, Egerton University and Meru University. This we hope if well adopted and utilized can reduce cases of unplanned pregnancies, depression, suicide cases, STI including HIV, alcohol and substance abuse and shape up career development among the students.

7 Conclusions

The App is a strategic intervention for tackling challenges facing students while in institutions of higher learning and so therefore a great tool for scale up.

Keywords: Mobile Application, Sexual and Reproductive Health, HIV and AIDS.

Acknowledgements

- UNESCO
- Sexual and Reproductive Health Alliance
- UoN CHIVPR
- University of Nairobi Students
- Ministry of Health (Reproductive Health Department, NASCOP, NACC).
- National Authority on Campaign Against Drug Abuse (NACADA)
- Fountain of Hope
- JHPIEGO
- KANCO
- Internews

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Strengthening capacity of government workforce on the management, triangulation and use of data for informed decision-making in Nigeria, 2021.

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Keywords: Capacity building (D057191)**,** Information systems (D007256)**,** Government (D006076)**,** Fellowship (D005257)

1 Background and Purpose

Nigeria's primary healthcare information system often relies on the technical skills of partners to compensate for limited in-country capacity. In 2018, the US Centers for Disease Control and Prevention developed and implemented a fellowship entitled Growing Expertise in E-health Knowledge and Skills (GEEKS). The aim of GEEKS is to strengthen technical capacity of Nigeria government staff on the management, triangulation, and use of routine immunization and integrated disease surveillance and response data for informed decision-making. We report on the cohort 2 implementation.

2 Methods

Participants are drawn from the Federal Ministry of Health, National Primary Healthcare Development Agency (NPHCDA), the Nigeria Centre for Disease Control (NCDC), the Federal Ministry of Health (FMOH) and the African Field Epidemiology Network (AFENET). Participants were trained on health information systems concepts, evaluation and problem-solving. Seventeen fellows were assigned into three sub project groups which are centered around triangulation of data from routine immunization administrative data systems, surveys, surveillance, vaccine logistics, and other standard data sources.

3 Results

When the current GEEKS cohort began training in October 2020, each subgroup developed a 12-month action plan. At the end of December, all operations were implemented as scheduled and officers are providing feedback and recommendations to improve performance and engaging in regular subnational capacity-building. Regular reports are submitted measuring progress against action plans.

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4. Conclusion

The GEEKS approach provides an opportunity for a comprehensive, hands-on transfer of capacity between fellows at all levels. Government personnel are expected to sustain ownership of all identified activities/tasks at all levels by the end of the 12-months fellowship.

4 Acknowledgements

This work has been supported by US Centers for Disease Control and Prevention directly and through the African Field Epidemiology Network.

Statement on conflicts of interest

There is no conflict of interest.

Journal of Health Informatics in Africa

Developing systematic procedures to strengthen Routine Immunization data quality and use across different sources in Nigeria

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Keywords: Data quality, Data use, DHIS2, Indicators

1 Introduction

Quality routine immunization (RI) data are necessary for effective program planning implementation. In Nigeria, the District Health Information System, version2 (DHIS2) and the Short Message Service (SMS) gateway are routine platforms for reporting RI data to the national level. Review of data captured on both platforms revealed substantial data quality issues and discrepancies. We examined efforts to strengthen RI data quality and use by developing systematic procedures to compare data from both sources.

2 Methods

Through the Growing Expertise in E-Health Knowledge and Skills (GEEKS) fellowship, officers from the Federal Ministry of Health, National Primary Health Care Development Agency and African Field Epidemiology Network collected baseline data and compared reports on the DHIS2 and SMS gateway using 17 indicators over a 3-month period (Aug-Oct 2020). Data compared include the number of children vaccinated, vaccine doses opened and sessions conducted; a >10% difference was considered a substantive data discrepancy. We also documented the frequency of feedback.

3 Results

Of the 17 project indicators assessed, only the number of BCG and OPV doses opened had <10% data discrepancy across both platforms. Although SMS and DHIS2 data are presented and discussed during weekly and monthly RI staff meetings, the project team developed a monitoring tool to track monthly progress on data quality and use and systematically providing feedback/recommendations to the states.

4 Conclusion

Routine monitoring and comparison of RI data reported on the DHIS2 and SMS platforms with systematic feedback and error collection will support efforts to strengthen RI data quality and use at all levels.

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Acknowledgements.

This work has been supported by African Field Epidemiology Network (AFENET) through a cooperative agreement with the US Centers for Disease Control and Prevention.

Statement on conflicts of interest.

The authors declare no conflicts of interest.

JHIA - online.org
Journal of Health Informatics in Africa

Interim analysis of government staff capacity to monitor and enhance the quality of Routine Immunization data through a new Fellowship approach to capacity-strengthening, Nigeria, 2021

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1 Introduction

Improving the quality – accuracy, timeliness and completeness – of routine immunization (RI) data is a priority for the Government of Nigeria and partners for effective managent of the program. One key component is building the capacity of health workers in the monitoring and use of RI data for decision-making. A capacity-building fellowship, The Growing Expertise in E-health Knowledge and Skills (GEEKS) project, was implemented in Nigeria. We examined how the capacity of selected national government staff fellows in the 2020 cohort was strengthened to conduct data quality checks and provide feedback to subnational level staff.

2 Methodology

Using a structured questionnaire, we assessed the baseline capacity before GEEKS enrollment of three fellows from the Federal Ministry of Health (FMoH) and National Primary Healthcare Development Agency (NPHCDA) in November 2020 on the use of the District Health Information System version II (DHIS2). During November 2020 to March 2021, fellows received hands-on and distance training on analyses of selected DHIS2 data quality indicators, using DHIS2 pivot tables and entering downloaded data into an Excel template for subnational feedback.

3 Result

At baseline, two of the three Fellows had rudimentary skills. As of March 2021, fellows can navigate the DHIS2 dashboard, use pivot tables to generate data quality analyses and download data for feedback, which has been sent to states for the first three months of implementation. Improvement in skills for each of individual fellows capacity at baseline and midterm is summarized in the figure below;.

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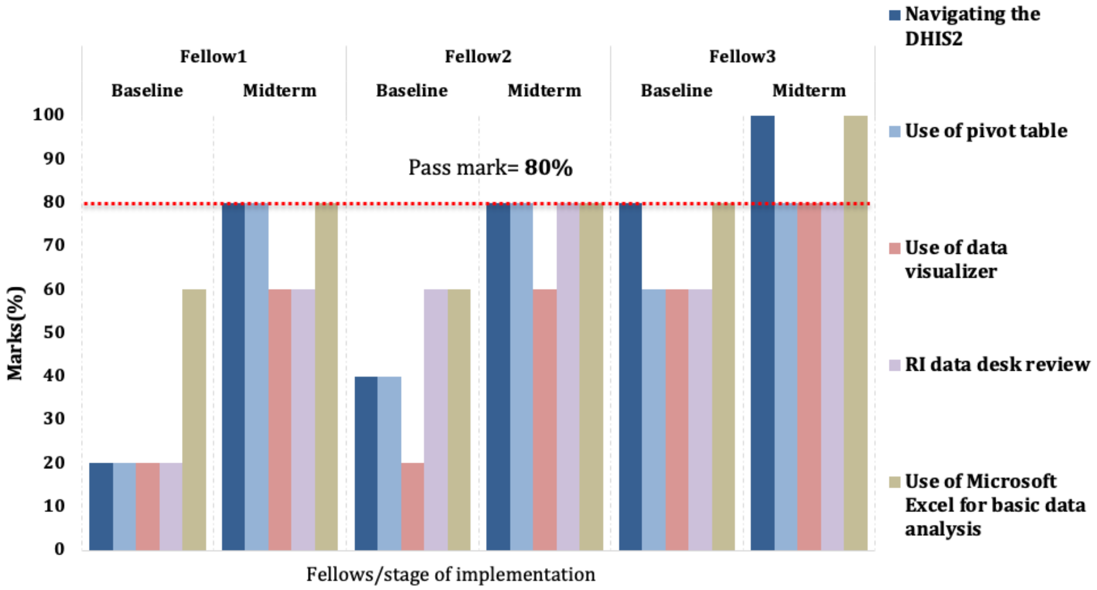
 J Health Inform Afr. 2020;7(1):12-23. DOI: 10.12856/JHIA-2020-v7-i1-266



4 Conclusion

Capacity building is an integral component of data quality improvement in publc health. Interim operational evidence after three months of implementation of GEEKS indicates that continuous capacity strengthening could lead to substantial improvements in RI data quality.

Keywords: Capacity building, data quality improvement, Government staff, Routine Immunization

Journal of Health Informatics in Africa

Expanding a DHIS2-based Disease Surveillance System to cater for COVID-19 case management and COVID-19 vaccine data management: Lessons learned from Sierra Leone

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Sierra Leone started monitoring for coronavirus disease 2019 (COVID-19) in February 2020. By then, the country had already established an electronic case-based disease surveillance (eCBDS) system for priority disease surveillance using DHIS2 platform and partially rolled it out to four districts covering about 30% of total health facilities in the country. The eCBDS was expanded to cover COVID-19 cases, contact tracing, and traveler tracking within 2-3 weeks, and then rapidly rolled out to the other 12 districts – initially only for COVID-19. The first COVID-19 case in Sierra Leone was confirmed in late March, and eCBDS was used to track all suspected and confirmed cases as well as confirmed deaths in the country.

Leveraging the capacities and resources already invested for the eCBDS system implementation, the Vaccine Technical Working Group within the COVID-19 Incident Management Command worked with partners (CDC, WHO, HISP-SA, and AFENET) to adapt the newly finalized IDSR 3rd Edition notification form and Acute Respiratory Infection case investigation form to cater for the COVID-19 specific requirements by the Ministry of Health and Sanitation (MoHS). Database hosting, user management, Master Facility List used for both eCBDS and the main HMIS in MoHS (also running on DHIS2 platform) kept running as before. Program indicators, reports, charts, maps, and dashboards were tweaked or expanded to cover COVID-19. As is common during high-profile epidemics/pandemics, other government departments, local and international partners introduced a few data capturing applications as necessary due to some deficiencies in DHIS2. However, currently there is an ongoing effort to clean and integrate all disparate data into the eCBDS.

In February 2021 the MoHS once again opted to expand the eCBDS by adding a Vaccine Registry Tracker Program that included a module for reporting adverse events following immunization (AEFI), based on a modified version of the standard COVAC Package developed by WHO and the international HISP network. Since March 2021, vaccination sites have used android tablets or laptops to register clients for vaccination, capture vaccine dose data, and if required capture any reported AEFI. The system tracks vaccine stock and doses administered, schedules appointments for the next dose, sends appointment reminders through SMS, and tracks missed appointments. We continue to improve the system by continuously evaluating user interaction and conducting usability tests and simulation exercises that depict real-life scenarios.

Currently the system is deployed in all 16 districts comprising of a total of 36 static and 16 mobile sites. Mobile sites were established to reach vulnerable or remote groups in the communities. Each vaccination site has a data entry clerk in charge of electronic data capture and a data officer stationed at the district. Data officers are trained and mentored to troubleshoot and resolve simple technical problems, and they also perform limited data analysis for use at a district level. In addition, advanced technical support to data entry clerks and data officers are provided through virtual calls and sharing of recorded videos illustrating data capture and analysis procedures for references. On-site visits are provided periodically to troubleshoot more complex challenges of the system. Paper-based data collection is maintained as a backup and data quality measure. Two months after mass vaccination was rolled out, 95% of the people who received 1st dose were captured in the vaccine tracking system. And people who were due for 2nd dose were tracked using a unique ID and sent appointment reminders. An interactive dashboard is established at the MoHS Department of Expanded Program for Immunization (EPI) to track vaccine stock, uptake, and coverage.

We aim to describe the agile development process used by Sierra Leone to quickly adapt a generic DHIS2-based system for case-based disease surveillance to cater to new requirements triggered by a global pandemic, lessons learned in the process, and the utility of data being collected through the system.

Journal of Health Informatics in Africa

Analysis of Objective Interestingness Measures in the Bidirectional Relationship Between Type 2 Diabetes and Hypertension at Nairobi Hospital, Kenya

Amos Otieno Olwendo

Background and Purpose: Diabetes mellitus is among the top 10 leading cause of death worldwide. The pattern of the coexistence of Type 2 diabetes mellitus (T2DM) and hypertension has lately drawn the attention of causality practitioners. This paper aims to analyse the interestingness of the pattern of the coexistence between T2DM and hypertension and explore the possibility of bidirectional causality between the two conditions in a diabetes mellitus dataset.
Methods: A retrospective study conducted on records of confirmed cases of diabetes mellitus collected between January 2012 and December 2016. This study was conducted at the diabetes clinic of the Nairobi Hospital located in Nairobi City, Kenya. The dataset was a stratified sample of male and female patients and the data was retrieved from the EHR database. The data were subjected to pre-processing; handling missing values, resolving inconsistencies, and identification and replacement of outliers. Thereafter, the dataset was imported into SQL Server 2014 database engine for storage and analysis.
Results: The average age of the participants was 53.4 years and 55% of whom were males. The prevalence of Type 2 diabetes and hypertension were 92% and 66% respectively. Systolic blood pressure of 140 mm Hg and higher were associated with 32.6% of the records. The causality between Type 2 diabetes mellitus and hypertension could be both interesting and complex. Exacerbation of T2DM affects both systolic and diastolic blood pressures.
Conclusions: The causality between T2DM and hypertension could be bidirectional and there is need to identify the confounding factors of interest.

Keywords: Objective measures, Knowledge discovery in databases, Hypertension, Type 2 diabetes mellitus, Causality

1 Introduction

The World Health Organization (WHO) lists ischaemic heart disease, stroke, kidney diseases, and diabetes mellitus (DM) among the top 10 principal reasons for the cases of mortality recorded in the year 2019 worldwide. A 2018 WHO report stated that non-communicable diseases are responsible for about 40 million mortalities yearly and diabetes was responsible for 1.6 million deaths worldwide. Low- and middle-income economies were projected to record nearly 92% rise in mortality due to diabetes [1], [2]. Urbanization and adoption of western dietary habits are cited as the main reasons for the increase in the number of cases of diabetes. Consequently, diabetes is the next epidemic in low-income countries [3].

Sub-Saharan Africa (SSA) is experiencing the fastest rates with regards to the prevalence of cases of diabetes worldwide. In 2014, about 0.5 million deaths were due to diabetes and 76% of patients were less than 60 years of age. Still, its projected that 41 million people in SSA will suffer from diabetes mellitus by 2035 the prevalence of diabetes shall have increased by 3% to 15% [4], [5].

In Kenya, most cases of diabetes experience late diagnosis and about 0.5 million Kenyans between 20 and 79 years had diabetes in 2015. In addition, the incidences of Type 2 DM (T2DM) in Kenya are about 90% of all the cases of diabetes. Moreover, the leading complications of diabetes in Kenyans include neuropathy, cardiovascular challenges and retinopathy [1], [6].

On the other hand, high blood pressure, also known as hypertension, is defined by blood pressure above 140/90 mm Hg and its considered severe at 180/120 mm Hg. Hypertension and Type 2 diabetes mellitus

(T2DM) happen to coexist and this coexistence results in the increased risk of the development of the complications of diabetes such as retinopathy, nephropathy, cardiovascular diseases among others [7]–[9].

However, causality practitioners have over time studied bidirectional causality between T2DM and hypertension and some results have dismissed possibilities for causality between T2DM and hypertension. On the other hand, other studies have suggested a T2DM → HTN and not the reverse. Nevertheless, these observational studies have not considered the potential sources of bias and the existence of confounding factors [10].

Still, a recent study that utilized the Mendelian randomization (MR), a method that minimizes the influence of confounding factors and bidirectional causality has been applied in the analysis of the causal relationship between T2DM and hypertension [10], [11]. The contribution of this research not only provided proof to support that T2DM is cause for the development of HTN but also classified cases of T2DM as either genetically instrumented or genetically determined T2DM. In addition, this study showed that the progression of T2DM is specifically causal to the exacerbation of the systolic blood pressure (SBP) thus does not have any causal relationship with the aggravation of the diastolic blood pressure (DBP). Therefore, this study only confirmed the relationship between T2DM and hypertension as T2DM → SBP and not the reverse [12].

Probability based interestingness measures in data mining

A data mining application has the potential of generating thousands or millions of patterns from data. However, the fundamental question is usually whether all the patterns generated by a data mining application are interesting, or rather, what makes a pattern interesting? There are nine classifications for objective measures of pattern interestingness. These measures are usually based on the structure of the discovered patterns and their corresponding underlying statistics. The key task in of an association analysis is to find frequent itemset, which are sets of items that frequently occur together in a transaction. Thus, association analysis if fundamentally concerned with defining new associations measures. Given a set of transactions, association rule finds rules that predict the occurrences of other items in the transaction [7], [13].

An objective measure is a data-driven approach for evaluating the quality of association patterns. Objective measures are usually based on the data only thus knowledge about aspects of the data is not considered. A pattern is general if it's represented in a large percentage of the data thus it measures the proportion of records in a dataset that matched the given pattern. An objective measure is usually computed based on the frequency counts tabulated from a contingency table [7].

Support as an objective measure of pattern interestingness.

An objective measure for the association rule of the form A → B is support. The strength of a frequent itemset is measured by its support, which is the fraction of transactions in which all items of the itemset appear together. Support represents the percentage of transactions from a database that the given rule satisfies. It also represents the probability Pr (A v B) where A v B indicates that a transaction contains the union of the itemset A and B. The threshold for support is usually greater than 50% [14], [15].

$$\textbf{Support } (A \rightarrow B) = \Pr (A \vee B) = \Pr (A) + \Pr (B) - \Pr (A \cap B)$$

Confidence as an objective measure of pattern interestingness.

The second objective measure for association rule is confidence. The strength of an association rule is measured by confidence of the rule, conf(A→B), which is the fraction of transactions containing all the items of A that also contain all the items of B. Confidence evaluates the degree of certainty of the detected association. This is the conditional probability P(B|A). That is, the probability that a transaction containing A also contains B [14], [15].

$$\textbf{Confidence } (A \rightarrow B) = \Pr (B|A) = \Pr (A|B) \Pr(B) / \Pr (A|B) \Pr(B) + \Pr (A|\neg B) \Pr (\neg B)$$

However, due to the known limitations of the support-confidence framework with a threshold of 50%, there are other alternative measures used to appraise the value of association patterns. However, due to the existence of a number of measures with varied results, this study selected alternative objective measures that also meet the three important properties of objective measures; the inverse property, null addition property, and scaling invariance property. Therefore, the selected objective measures include; cosine (IS), Odds ratio, correlation, and Jaccard [7], [16], [17].

Cosine as an alternative measure of pattern interestingness.

Cosine is a measure for similarity between two sequence of numbers and it can bet calculated as [17];

$$\mathbf{Pr\ (AB) / \sqrt{Pr\ (A)\ Pr\ (B)}}$$

Odds ratio as an alternative measure of pattern interestingness.

Odds ratio is a measure that enumerates the strength of an association among two variables A and B. Events A and B are independent if and only if their Odds ratio is equal to 1 and correlated if their Odds ratio is greater than 1. Also, when the Odds ratio is less than 1 then variables A and B are negatively correlated and the presence of one variable reduces the Odds of the other. The Odds ratio between A and B can be calculated as [17];

$$\mathbf{Pr\ (AB)\ Pr\ (\neg A \neg B) / Pr\ (A \neg B)\ Pr\ (\neg BA)}$$

Correlation as an alternative measure of pattern interestingness.

Linear correlation coefficient measures linearity among two random variables. Correlation coefficient is the covariance between two variables divided by their standard deviation. This relationship can be represented as [17];

$$\mathbf{Pr\ (AB) - Pr\ (A)\ Pr\ (B) / \sqrt{\ Pr\ (A)\ Pr\ (B)\ Pr\ (\neg A)\ Pr\ (\neg B)}}$$

Jaccard as an alternative measure of pattern interestingness.

Jaccard similarity coefficient is used to measure the likeness and variety of sample sets. Jaccard coefficient is the size of the intersection between sets A and B divided by the size of the union of the sets A and B. Jaccard coefficient is calculated as [17];

$$\mathbf{Pr\ (AB) / Pr\ (A) + Pr\ (B) - Pr\ (AB)}$$

2 Materials and methods

A cross-sectional study conducted at the Nairobi Hospital located in Nairobi City County, Kenya. All the relevant ethical approvals and permissions were obtained from the relevant bodies that include National Commission for Science, Technology and Innovation (NACOSTI) and ethical review board of Nairobi hospital. Thereafter, a stratified sample of 653 records of male and female with confirmed cases of diabetes mellitus collected during routine care and stored in the Electronic Health Record (EHR) database between 1 January 2012 and 31 December 2016 were retrieved from a population of 1200 records of patients and analysed in this research.

The sampled data; had at least one confirmed diagnosis for diabetes mellitus as identified by International Classification of Disease version 10 code (ICD 10) codes E10 – E14. Also, the records sampled did not include diagnoses for co-morbidities except for hypertension as identified by the ICD 10 codes I10 – I15. Finally, each record of data must have been associated with a gender attribute identified as either male or female.

Data were subjected to pre-processing that involved handling cases of missing values, smoothing for the removal of noise, identification and replacement of outliers, and resolving cases of inconsistencies. The dataset was imported into the SQL Server 2014 database management system (DBMS) for storage and analysis.

Descriptive numerical methods for measures of central tendency and frequency distribution were conducted using SPSS version 21. Also, structured query language (SQL) commands on the DBMS. SQL queries focused on the counts of the number of transactions for records with both T2DM and HTN, records with T2DM and SBP $\geq$ 140 mm Hg, and records with both T2DM and DBP $\geq$ 90 mm Hg. Probabilities of the results were likewise calculated and used to affirm the support and confidence in the premises for bidirectional causality between T2DM and hypertension, T2DM and systolic blood pressure (SBP), T2DM and diastolic blood pressure (DBP), and between T2DM and the combination of SBP and DBP. Alternative objective measures of interestingness; cosine, Jaccard, Odds ratio, and Linear correlation coefficient were also calculated for premises above.

3 Results

There were 1200 records in the EHR database and only 54% (653/1200) had confirmed diagnoses of T2DM and hypertension. A total of 81% (532/653) of participants had Body Mass Index (BMI) greater than 25, 55% (358/653) were males, an average age of 53.4 and 92% of the participants were aged between 40 and 82 years. Similarly, the probabilities for T2DM and hypertension calculated as; Pr (T2DM) = 600/653 = .92, and, Pr (HTN) = 434/653 = .66 respectively.

The prevalence of complications of diabetes were highest for retinopathy 12% (78/653) followed by neuropathy 11% and cardiovascular 11% respectively. Other complications were disorders of lipoprotein 7%, high cholesterol 5%, and depression and foot damage that were 4% respectively.

3.1 T2DM → HTN and the reverse

The support for the claim that the development of T2DM would result in the development of hypertension was 95% with a confidence of 86%. On the other hand, the confidence in the belief that the development of hypertension results in the development of T2DM represented as HTN → T2DM had a support of 95% with a confidence of 94%. Likewise, the correlation between T2DM and HTN was 0.003. The other details for the relationship between T2DM and hypertension in the diabetes dataset are as reported in Table 1.

Table 1. The relationship between T2DM and Hypertension in the diabetes dataset.

Enquiry	Frequency (N = 653)	Probability (Pr)
f_{00}	27	.0413
f_{01}	25	.0383
f_{10}	190	.2910
f_{11}	409	.6263

3.2 T2DM → SBP and the reverse

The probability that systolic blood pressure was greater than or equal to 140 mm Hg among the diabetes dataset represented as Pr (SBP >= 140) was 0.326 (213/653). Moreover, the claim that the development of T2DM is the reason for the exacerbation of the systolic blood pressure had a support of 99% with a confidence of 84%. On the other hand, the claim that the exacerbation of the SBP is the reason for the development of T2DM had a confidence of 90%. Also, the correlation between T2DM and SBP was 0.209. The rest of details for the relationship between T2DM and SBP in the diabetes dataset are as reported in Table 2.

Table 2. Relationship between T2DM and Systolic blood pressure in the dataset.

Enquiry	Frequency (N = 653)	Probability (Pr)
f_{00}	1	.0015
f_{01}	12	.0184
f_{10}	32	.0490
f_{11}	168	.2570

3.3 T2DM → DBP and the reverse

That likelihood that the diastolic blood pressure was greater than or equal to 90 mm Hg among the diabetes data epitomised as Pr (DBP >= 90) was 0.211(136/653). Besides, the premise that the development of T2DM is the reason for the exacerbation of the diastolic blood pressure had a support of 97% accompanied with a confidence of 86%. Alternatively, the claim that the exacerbation of diastolic blood pressure was the reason for the development of T2DM had a confidence of 91%. Also, the correlation between T2DM and DBP was 0.318. The other details for the relationship between T2DM and DBP are shown in Table 3.

Table 3. Relationship between T2DM and diastolic blood pressure in the dataset.

Enquiry	Frequency (N = 653)	Probability (Pr)
f_{00}	1	.0015
f_{01}	11	.0168
f_{10}	18	.0276
f_{11}	108	.1654

3.4 T2DM → (SBP and DBP) and the reverse

The chance that the combined effect of the systolic and diastolic blood pressures greater than or equal to 140- and 90-mm Hg respectively represented as Pr (SBP >= 140 and DBP >= 90) had a probability of 0.1547 (101/653). Besides, the claim that development of T2DM resulted in the exercitation of both SBP and DBP had a support of 96% and a confidence of 86%. Likewise, the reverse claim that the exacerbation of both the SBP and DBP were the cause for the development of T2DM had a confidence of 90%. The rest of details for the relationship between T2DM, SBP, and DBP are summarized in Table 4.

Table 4. The relationship between the existence of T2DM and Systolic and Diastolic blood pressures in the diabetes dataset.

Enquiry	Frequency (N = 653)	Probability (Pr)
f_{00}	1	.0015
f_{01}	9	.0138
f_{10}	13	.0200
f_{11}	78	.1194

3.5 Comparison of results for Support and Confidence and selected alternative objective measures of interestingness on the diabetes dataset.

Table 5 shows a summary of the results for the support and confidence in the interestingness in the patterns in the diabetes dataset.

Table 5. Summary of the results for the objective measures of pattern interestingness between T2DM and hypertension

Premise (x)	Support	Confidence	Cosine	Jaccard	Odds ratio	Correlation Coefficient
T2DM → HTN	0.95	0.86	0.80	0.66	0.16	0.15
HTN → T2DM	0.95	0.94	0.80	0.66	0.16	0.15
T2DM → SBP	0.99	0.84	0.47	0.26	0.38	-0.34
SBP → T2DM	0.99	0.90	0.47	0.26	0.38	-0.34
T2DM → DBP	0.97	0.86	0.37	0.17	0.05	-0.26
DBP → T2DM	0.97	0.91	0.37	0.17	0.05	-0.26
T2DM → SDBP	0.96	0.86	0.32	0.12	0.46	-0.23
SDBP → T2DM	0.96	0.90	0.32	0.12	0.46	-0.23

4 Discussion

The results from this analysis of pattern interestingness with regards to the coexistence between T2DM and hypertension are both interesting and perplexing. The relatively high values for both the support and the confidence for the bidirectional relationship between T2DM and HTN depict high reliability of the association rules for the relationship between T2DM and hypertension. Just like observed by [18], [19], results in this study show that the relationship between T2DM and hypertension is more complex than believed.

All the literature reviewed refuted the possibility of hypertension being a cause for the development of T2DM (HTN → T2DM). However, results from this analysis show that the confidence in the event that HTN → T2DM is much higher than the probability for the occurrence of the event T2DM → HTN. However, the bidirectional relationship between HTN and T2DM is also supported by both the cosine similarity and by the Jaccard similarity coefficient between the two variables

Moreover, the present belief in the medical literature supports the premise HTN → T2DM and not the reverse. However, it is interesting to note the closeness of both the support and the confidence values for the premises T2DM → HTN and T2DM → SBP respectively. On the other hand, it is as well interesting to note that 63% of the cases of T2DM had hypertension as a co-morbidity. The premise for the relationship between T2DM and HTN had the only positive correlation coefficient [3].

Besides, the study by [11] reported the claim that T2DM → SBP. Likewise, the result from this study had a confidence of 84% on the above claim. However, the reverse relationship between T2DM and SBP (SBP → T2DM) happens to present a much higher confidence (90%). Also, the Odds ratio for the relationship between T2DM and SBP poses a higher value than for the relationship between T2DM and HTN meaning that the strength between T2DM and SBP is much stronger thus mostly likely to be expected.

In addition, [11] reported that no causality exists between T2DM and DBP. However, the confidence in the premise T2DM → DBP and the reverse posted much higher probabilities than T2DM → SBP and the reverse. The results from this study show that a causal relationship between T2MD and DBP does exist. Despite the high confidence in the relationship between T2DM and DBP in comparison to the confidence in the premise T2DM → SBP, the cosine and Jaccard similarity coefficient values are both higher and consistent for the premise T2DM → SBP. Likewise, the Odds ratio values are also higher for the premise T2DM → SBP and reverse in comparison to the Odds ratio values for the premise T2DM → DBP and reverse.

Similarly, the claim that T2DM is the cause for the exercitation in both the SBP and DBP did equally present reasonable results compared when each of the blood pressure types were analysed individually. Odds ratio value for the combined effort of SBP and DBP was much higher than for the case of each of the variables individually. Also, both SBP and DBP had negative correlation with T2DM yet their combined efforts had a much stronger linear correlation coefficient with T2DM.

This study had some limitations which the fact that it conducted an observational study using historical dataset that were primarily collected during the provision of routine healthcare services. Therefore, none of the biases and confounding factors were considered to have had any effect on the data analysed in this study. Furthermore, a better analysis of the association of variables in database records may pose better and consistent results in the event that the sample size is much larger. A number of studies that have conducted an analysis for the causality between hypertension and T2DM have worked with thousands and hundred of thousands of records.

In conclusion, the co-existence between T2DM and HTN is quite interesting and complex as the two conditions share an intertwine etiology. Presently, medical literature believes that hypertension is the cause for T2DM and not the reverse. However, the causality practitioners refute the possibility of

HTN → T2DM. Instead, causality practitioners believe premised T2DM → HTN and T2DM → SBP are the only causal associations. Though, this study believes that the premise T2DM → DBP and/or the reverse is also causal and should never be ruled out. As a result, the causality between T2DM and HTN needs a more organized study that implements multiple methods for the analysis of the causal analysis among the variables of interest.

Statement on conflicts of interest

There is no conflict of interest in this work.

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Journal of Health Informatics in Africa

A Novel KenyaEMR implementation to scale up TB/HIV program monitoring and reporting in all health facilities in Homabay County.

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1 Background and Purpose

Elizabeth Glaser Paediatric AIDS Foundation (EGPAF), through The President's Emergency Plan for AIDS Relief funding, has supported HIV service provision in Homa Bay County since 2010 utilizing both electronic (KenyaEMR) and paper-based records to document patient management in 165 supported sites. As of October 2020, 52 (31.5%) sites were on KenyaEMR covering 50.3% of the total patients current on antiretroviral therapy (Tx_Curr) with 6 sites on point of care while 46 on retrospective data entry. Traditional deployments of electronic medical records (EMR) in health facilities have faced significant challenges namely: huge upfront setup costs, need to burglar proof all EMR rooms, theft of computers, frequent main grid power outages, long turnaround time (TAT) for technical support and lack of access to real time data for above-site use. A novel solution was therefore required to effectively scale up and promote use of EMRs in health facilities.

2 Methods

EGPAF worked with Palladium Group, the Health Management Information Systems partner, to develop a cloud-based computing solution to: a) effectively scale up EMR implementation to all health facilities and all points of the HIV care continuum, b) reduce implementation costs through use of tablets and c) enhance real time data availability for clinical and program monitoring and reporting at all levels. The solution was developed by reviewing and learning from the concepts utilized in already running cloud implementations including Ushauri (an electronic patient appointment management system), TIBU (a centralized electronic health records system for TB patients), Kenya Health Information System (KHIS) for in-patient records and the findings from a Cloud EMR pilot in Kakamega. The proposed solution was discussed with the Ministry of Health (MOH), Homabay County and CDC, and revised based on inputs received.

The cloud solution has the following key components:

1. Android tablets: Utilized as facility end user devices to access KenyaEMR.
2. Solar charging stations: Small scale solar installations for charging tablets.
3. Digital Safe: Secure storage facility for tablets
4. Private Access Point Name (Private APN): Secure Global System for Mobile Communications (GSM) cellular network to access remote EMR servers through tablets.
5. Virtual private network (VPN): Private network to access the servers through the internet by program level staff and MOH managers.
6. Mobile device management software: Software installed in tablets to restrict access to unauthorized applications, prevent theft of tablets and remote support to tablets.
7. Virtual machines: Servers located in a Tier 3 data centre to provide computing and storage services for EMR application.

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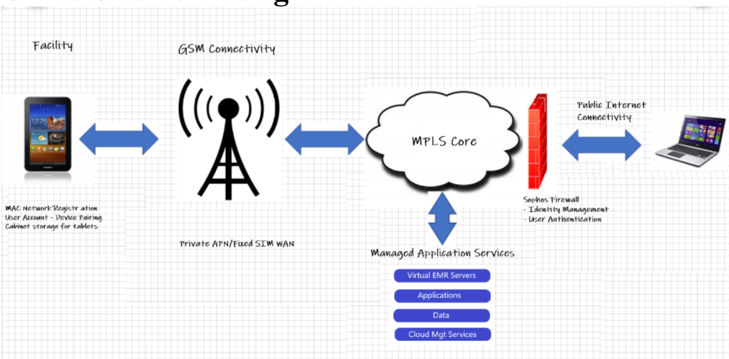
Cloud Solution Design



KenyaEMR instance is installed in one virtual machine whose image is then replicated in all other virtual machines. The virtual machines are within a Multi-Protocol Label Switching (MPLS) core at the cloud data centre. Health facilities access their respective EMR applications through a private APN linked to an MPLS backhaul. An automated script upgrades all virtual machines with new KenyaEMR versions. All data remains in-country.

3 Results:

EGPAF successfully deployed KenyaEMR in 164 sites (91% Tx_Curr) within six months. TAT for technical support has reduced from 2-5 days to a maximum of 30 minutes. All sites receive EMR upgrades within 24 hours of new version release. Program team remotely reviews site level data resulting in timely virtual support amidst COVID-19 pandemic. Index testing data is entered real time even when the services are provided at the community. EMR data is uploaded to the National Data Warehouse automatically on the first day of each month. Increased data use at program level is progressively improving data quality.

4 Conclusion:

Cloud EMR solution is highly adoptable for timely clinical and program monitoring including reporting to a central national data repository. This solution can be scaled up to all TB/HIV service delivery points especially in countries where current EMR coverage is sub optimal. The EMR application should be redesigned for optimal utilization of cloud resources through multi-tenant support in orchestrated containers.

Keywords: KenyaEMR, Cloud, Tier 3 data centre, private APN, MPLS core, Virtual machine, Virtual private network, Android tablets.

Journal of Health Informatics in Africa

Revisiting Health Information Exchange in Low Resource Settings: Modes of Health Record Transmission

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Background and Purpose: Patients are increasingly seeking care from multiple institutions and practitioners, making it necessary for practitioners using disparate electronic health record (EHR) systems and in different geographical locations to access a shared patient record. Health information exchanges (HIEs) that can uniquely identify patients through a master patient index and accurately aggregate the patient's health records across different health are needed for continuity of quality healthcare. We explore the suitability of different transport mechanisms for health information sharing in low- and middle-income country (LMIC) settings.
Methods: We conducted a literature search to identify common information transportation methods used in HIEs. We then applied a scenario to access how information would be transferred and whether it would lead to a complete patient record.
Results: We identified three modes of health information exchange that have been documented in literature. Paper printouts are a tradition and still widely used method for information exchange that suffer from a need to re-record patient records. Electronic patient record repositories allow seamless transfer of health records but are overly dependent on availability of reliable network connectivity. Smartcards offer a patient held means of transporting health records but are limited by implementation costs and finite storage space.
Conclusions: The assumption of reliable and near real-time network connectivity for health information exchange does not hold in many LMIC settings. The use of 2-dimensional barcodes for transferring patient information between health facilities presents a low-cost alternative that can be used to augment the performance of existing and future HIEs.

Keywords: Electronic Health Record, Master patient index, Health information exchange, LMIC, Low-resource settings

1 Introduction

Many institutions and governments including those in low- and middle-income countries (LMICs) have adopted electronic health records (EHRs) to coordinate and improve care and outcomes of patients[1]. EHRs are a digital collection of health information about an individual for the purposes of continuity of care, education, and research. In this article, we define the electronic healthcare record and present its purpose as a tool for continuity of care. We briefly describe the current situation of usage and focus on the major challenges to wide implementation in Europe and beyond. Finally, we point out trends that show stronger involvement of the patients-citizens in the health care prevention and promotion processes and discuss the impact on the future development of the electronic healthcare record into personal health records. As envisaged in the 1990s, one of the benefits of an EHR is the ability to access complete patient data including imaging diagnostics and laboratory test results at anytime and anywhere by authorized personnel[2]. Allowing multiple users to simultaneously access a patient record within the same institution is relatively straightforward and is seen as another benefit of EHRs[3]. However, patients are increasingly seeking care from multiple institutions and practitioners, making it necessary for practitioners using

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disparate EHR systems and in different geographical locations to access a shared patient record[4]. A shared health record gives access to a patient's set of records across health programs and health institutions in order to improve the patient's outcomes[4].

To facilitate sharing or exchanging patient information between EHRs, patients must be accurately identified across the different systems. Unique patient identification is a complex feature of health information exchange that is often assumed and treated as a foregone conclusion[5]. To uniquely identify patients across facilities and locales, an organized storage of patient demographic information for the purpose of uniquely identifying individual patients through the assignment and use of a unique identifier otherwise called a master patient index (MPI) is required[6]. The use of a shared unique identifier as assigned by an MPI helps aggregate patient information across health facilities into a complete patient health record thereby ensuring the continuity of care and potentially preventing some medical errors[7].

Laboratory test results have been a use case that many countries in LMICs have cited as an example for the need of exchanging the patient record[8], [9]. To achieve this, a system that can aggregate a patient record across the different health institutions is required. A system that serves this role is known as a health information exchange (HIE). An HIE may be defined in multiple ways but one common description is that it is the infrastructure that enables the exchange of the patient record with the goal of improving the patient care process, improving patient satisfaction, and removing redundancies in care due to repeated assessments and diagnostic tests[10]. Using the unique identifier issued by an MPI, the HIE pulls together patient records from disparate EHR systems either in real-time or on-demand.

Many LMICs have started discussions and even initiatives to enable health information exchange[11]–[14]. Countries that have implemented HIEs have designed them differently and with different building blocks. In an analysis of the status of HIEs in six different countries with different economic levels of development, several technical and policy infrastructural components were expected to be in place such as the presence of EHRs, communication networks, and appropriate legal frameworks to enable the exchange of information[10].

As much as there has been varied progress and success in the implementation of the HIEs[10], several challenges still remain in their implementation and success especially in LMICs. In this paper, we discuss several transport mechanisms that have been implemented to enable health information exchange with an example scenario, and we propose an alternative for low-resource settings where network connectivity is often unreliable and electronic systems may not always be available. We define a transport mechanism as the medium that enables the movement of health information from one health facility or institution to another.

Scenario: Disimoni Mahilasi is a 24-year-old man who tested positive for HIV at the age of eight. For 7 years after he was first diagnosed with HIV, Disimoni was on pre-antiretroviral therapy as he did not meet the criteria for starting anti-retroviral therapy (ART). On 1st February 2012, his CD4 count came back at 287 cells per cubic millimeter and he was started on ART. He has been enrolled in the ART clinic at Sangala Health Centre for nine years and is currently on the 5A regimen with an adherence of 92%. The health center has an EHR in the ART clinic and ambulatory departments through which Disimoni was issued a unique Health ID from a central database containing a finite pool of unique health IDs. Disimoni has received a promotion and needs to transfer to the City where he plans to continue receiving care at a health facility in the City.

2 Methods

We utilized descriptions of designs and implementations of HIEs in published literature to identify transport mechanisms for HIEs. Each transport mechanism was then assessed based on how information in the given scenario would be transported or made available to other health facilities. We further assess the mechanism based on factors reported in published literature that we have deduced as important from the goals of HIEs and from reported barriers of implementing HIEs. The following factors are used as part of the assessment transportability, reliability, effectiveness, completeness, and implementation cost[9].

3 Results and Discussion

To begin with, there are two mutually exclusive possibilities on the availability of patient information and the transport mechanism. Assuming the presence of an EHR system at any facility, we summarize these possibilities in Table 1 and discuss the different options in terms of HIE.

Table 1: A summary of all the possibilities on availability of patient data at a health facility.

		Brought by Patient	**Not Brought by Patient**
Patient Information in Health Facility EHR System	**Available**	Patient records available through HIE but the patient also brought records.	Patient records available through HIE only.
	Not Available	No HIE but the patient brought records.	Typical of first patient encounter.

Starting from the bottom right option in Table 1, this represents the classic first encounter of a patient at a health facility. At this point, the patient's demographic details, medical history, and some clinical consultation details possibly including a medication prescription will be recorded. On the subsequent visit to another health facility for the same or different ailment, the patient will either find that the details that were recorded on the past visit exist or do not exist. In the case where the details do not exist, we assume that the two health facilities are not connected to share health information. In this case, some details from the previous encounter will have to be re-entered into the EHR and saved (bottom left option in Table 1).

The ideal case for HIE is the top right option in Table 1 where a patient shows up at a health facility for the first time without bringing their previous health records and the healthcare provider is able to uniquely identify the patient in the system and access their health record. In this situation, the patient's unique identifier can be used to retrieve the health record eliminating the need for recapturing the patient's previous data.

Next, we explore the different mechanisms employed by different HIEs. From the literature review, we identified three different mechanisms for transferring patient data: paper printouts, electronic repositories, and smart cards.

3.1 Printouts of patient records

Perhaps the most traditional way of transferring medical records between health facilities is through the use of paper printouts transmitted by fax, email or by hand[15], [16]. The majority of health facilities in LMICs have not completely eliminated the use of paper in their health facilities despite the adoption of EHRs[17]. This is due to a number of reasons among them inadequate funds to support the universal rollout of EHRs within and across health facilities to all points of need. Furthermore, due to unavailability of reliable electricity and power backups, most EHR implementations operate in parallel with paper-based systems as a backup to the EHR[18], [19]. Nevertheless, most LMICs that have adopted EHRs in these settings have implemented them in a way to coordinate care from one point of care to another[6]. However, it is common to find EHR modules that support some but not all health services provided at a health facility. Most sites lack connectivity for all points of care within the facility and with other health facilities.

To respond to the scenario above, health facilities would in most cases make a printout of Disimoni Mahilasi's record which he would have to bring to the facility in the city for enrollment and continuation of care. To simplify and reduce the data entry task, it is highly likely that only the mandatory fields would be recorded with most of the patient record potentially ignored and lost. There would also be the possibility of the record not being entered at all faced with barriers to technology such as resistance at the City health facility. Therefore, as much as printouts remain a popular method for patient transfer outs, we observe that challenges remain in ensuring that a full record is exchanged between the source health facility to the target health facility. As such, the benefits of HIEs such as reducing the need for redundant testing and using past medical history for decision support are not achieved.

3.2 Electronic Patient Record Repositories

Three core architectures underlie electronic patient record repositories; centralized, distributed, and replicated architectures[20], [21]. In the centralized architecture, all patient records are stored in one location that is connected to all the health facilities. On demand, the patient record is viewed or retrieved from the central repository in real-time. This requires that the local health facility has a reliable network connection to the central repository and that the connection and central repository are always available when needed. In this model, the central repository can be seen as a single point of failure.

The distributed system resolves the single point of failure in the centralized architecture by storing and managing patient records in multiple locations[20]. However, users from any location have access to all the data as if it were all stored in the same place through the use of federated queries that search the both the local and remote database instances. This architecture requires that each EHR system instance be connected to all the other instances. Unlike the centralized architecture which fails if the connection to the central location is unavailable, the distributed architecture allows remote instances to continue functioning even when there is no connection to one or more of the other locations.

A replicated architecture goes further than the distributed architecture in that each facility stores a copy of all the patient records from all the other facilities. Unlike the centralized and distributed architectures that require real-time network connectivity, a replicated architecture requires frequent but not continuous connectivity[21]. As patient encounters are recorded, the updates are slowly pushed through the nodes of health facilities so that the data remains consistent across all locations. Furthermore, this architecture does not require that all health facilities are connected to each other, just that there are enough redundant links to handle faulty connections.

All three electronic patient repository architectures rely on a reliable network connection for communication between facilities and a unique patient identification framework to ensure that the right patient record is retrieved. In the case of Mr. Mahilasi, working network infrastructure will be required to facilitate the transfer of his record in the absence of which his complete health record may not be available at the City clinic.

3.3 Smart Cards

Smart cards provide an alternative portable wallet-sized means of transporting patient records between health facilities[22]. A smart card is a plastic card with a programmable microchip that stores data, which can be read with an appropriate card reader[23]. The implementation of this mode of health information exchange was scaled up in some countries in response to challenges in network infrastructure. Notably this approach was implemented in the African country of Zambia where patients accessing Ante-natal care services and those in ART clinics were provided with a smart card[24]–[26]. In the scenario above, Mr. Mahilasi would have his record on the smart card and the city clinic would read the patient record and register him as a new patient at the health facility.

While attractive, one shortcoming of smart cards is that the cards used have to follow the same standards potentially leading to vendor lock-in and high prices. Furthermore, smart cards have a finite amount of memory limiting what can be written on the smart card microchip for storage[27]. We anticipate that the smart card would meet the needs of our scenario. However, the costs of scaling up such a system to all health facilities would be significant as most devices capable of reading and writing on smart card are not cheap[28], [29]. Another point to consider is that the smart card would need to be safely kept by the patient for re-use. In the case that the patient loses the card, then he may be re-issued a new one but at a cost. This of course could be negligible with current reductions in memory costs, but nevertheless, the cumulative cost would be substantial.

3.4 2-Dimensional barcodes

Ideally, each health facility should have an EHR that is connected to EHRs at other health facilities enabling the sharing and exchange of patient records when needed. However, many health facilities in low-resource settings still do not have integrated, hospital-wide EHRs let alone, EHRs that are part of a regional, district or national network for sharing and exchanging health information[9]. We propose a solution that augments the care process in places where EHRs may be available but network availability is problematic.

Barcodes have been used as a method of representing information for a long time but mostly in the supply and logistics fields to reduce transcription errors and achieve fast retrieval of information[30]. In Malawi, barcodes have been used for printing unique patient identifiers using one dimensional barcodes[31]. This method has been extended to represent identifiers for other services such as identifying laboratory specimens[32]. The representation of patient IDs using barcodes has been successful such that more than 5 million people in the country have been issued a unique identifier on a barcode[33]. That being said, the re-identification of patients at different facilities has been reliant on connecting to a central demographics exchange that systematically synchronizes with a local health facility database[34]. However, this could easily be resolved through the use of 2-dimensional barcodes and the appropriate barcode scanner, technology which overtime has become a more accessible, scalable and affordable mode of transporting information[35]. Since January 2020 a pilot implementation has been carried out at Kamuzu Central Hospital that uses 2-dimensional barcodes to transport patient demographics[32].

The use of 2-dimensional barcodes can be further used to facilitate the continuity of care. In Figure 1, we present how the medical history of the patient in our scenario could be shared with another health facility.

Patient Name: Disimoni Mahilasi (M)

Date of Birth: 27 July 1997

HIV Positive Test: 23 October 2005

ART Started: 1 February 2012

Reason for Starting: CD4 < 350

Current Regimen: 5A (1 May 2018)

Current Adherence: 92%

Allergies: Sulphur

Figure 1: A sample continuity of care QR-code.

In requesting his transfer from Sangala Health Center, Mr. Mahilasi would get the details from his medical record summarized and printed on an adhesive label with the details as shown in Figure 1. In the context of the Malawian health care system, this adhesive label could be affixed in Mr. Mahilasi's health passport, a paper-based continuity of care document kept by the patient[32]. Upon arrival at the city clinic, Mr. Mahilasi need only present his health passport and the healthcare provider can scan the QR code to create a complete patient record. In the absence of a barcode scanner capable of scanning the QR code, the human readable text printed on the label in Figure 1 could be used to enroll him in the treatment program at the new facility.

We believe that 2-dimensional barcode technology may meet most use cases for health information exchanges owing to their ability to transport more patient information and their low cost of implementation[36]. Given the current infrastructure challenges and limited budgets, an HIE based on data exchange via connectivity networks alone would not be the ideal mechanism for most use cases in LMICs. However, augmentation with 2-dimensional barcodes can make HIE implementation in LMICs more successful[31].

3.5 Summary of Benefits of Transport Mechanisms for HIEs

In Table 2, we summarize the different mechanisms for health information exchange by putting a score out of five stars for some of the factors that we have discussed in the positions we have taken for the different mechanisms above.

Table 2: Comparison of alternative data transport mechanisms for HIE

Mechanism	Transportability	Reliability	Effectiveness	Completeness	Implementation Cost
Printouts of patient records	✦✦✦✦✦	✦✦✧✧✧	✦✦✦✦✧	✦✦✦✧✧	✦✦✦✦✦
Electronic Patient Record Repository	✦✦✦✧✧	✦✦✧✧✧	✦✦✧✧✧	✦✦✧✧✧	✦✦✧✧✧
Smart Cards	✦✦✦✦✦	✦✦✦✦✧	✦✦✦✦✦	✦✦✦✦✦	✦✧✧✧✧
2-D barcodes	✦✦✦✦✦	✦✦✦✦✦	✦✦✦✦✦	✦✦✦✦✧	✦✦✦✦✧

4 Conclusion and recommendation

Health information exchange between facilities serving a common patient population is necessary and the rise of global epidemics such as the current COVID global pandemic highlights the need for inter-country HIEs [8], [12]. Given the fact that most LMICs have limited reliable network infrastructure, it is important to explore mechanisms that take the poor infrastructure into account in order to design effective HIEs. We make the observation that most strategic plans for implementing HIEs in LMICs make the assumption of centralized access to some form of patient data repository having adopted the OpenHIE framework[12]. We are of the view that the existing infrastructure needs to be augmented with affordable, simple, secure and scalable mechanisms for information sharing. Given the different mechanisms discussed in this paper, we believe that 2-dimensional barcodes such as QR codes may be the transport layer for HIEs and augment the current HIE design and eventual implementation.

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Electronic Medical Record System Improves Antiretroviral Treatment Data Quality and Use: Experience from 111 Health Facilities in Ethiopia

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1 Background

Data quality and data use were major gaps in HIV/AIDS program implementation in Ethiopia. An enhanced eelectronic medical record antiretroviral treatment (EMR-ART) system was instituted in more than 470 health facilities in the country during the period from March 15, 2018. to September 30, 2020. An integrated and standardized HIV data quality improvement and data use initiative was implemented at 111 of the high HIV patient load health facilities in five regions during April 2019-September 2020. Experience gained in designing and implementing the system is presented with the results achieved through this newly introduced system.

2 Intervention

The Ministry of Health (MOH), Regional Health Bureaus (RHBs), ICAP at Columbia University (ICAP) and the U.S Centers for Disease Control and Prevention (CDC) deployed an

EMR-ART based data quality improvement (DQI) and information use initiative using multi-pronged and synergistic approaches to continuously identify and solve longstanding data quality and use issues and challenges. Standard operating procedures (SOPs), and monitoring tools including tools for data entry verification, mentorship, and online reporting, and innovative approaches for communication and monitoring such as Telegram group and Google Drive were developed and utilized. A multidisciplinary team was trained on DQI procedures. The team conducted pre- and post-initiative assessments and supported health facilities through onsite and virtual mentorship. Patient information was entered by the clinician into a paper chart and, after the visit, a data clerk enters the information into EMR-ART database. A baseline data quality audit was conducted using 2,109 randomly selected patient charts to assess the level of data completeness and accuracy of both paper and electronic records. In addition, a total of 422,529 active charts were identified from all 111 facilities and the EMR-ART system and ARTregisters were updated. The EMR-ART system was enhanced to meet ART service-related DQA and reporting requirements.

3 Results

The baseline audit found that data completeness was <50% for demographic data such as district [39%], telephone number [49%], and house number [8%]; <20% for WHO staging at enrolment; 21% for tuberculosis preventive therapy (TPT) start date and 27% for completion date; and 49% for HIV viral load

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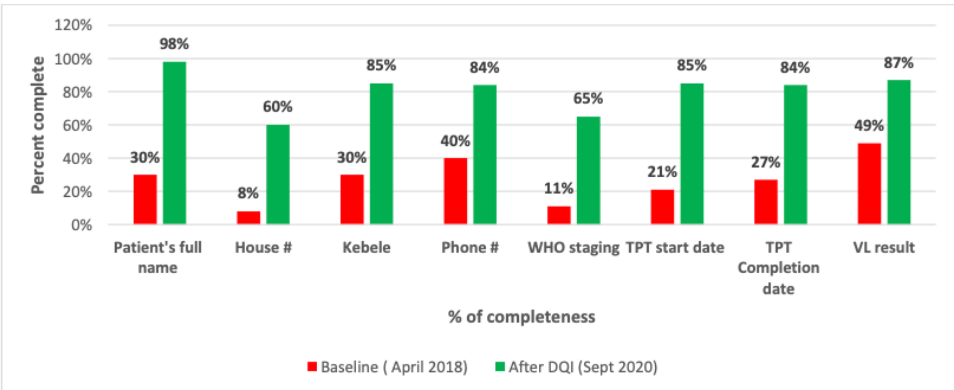
(VL) test results. Overall, 264,289 (63%) of the charts reviewed had gaps in demographic and/or clinical data completeness. After the intervention, a remarkable improvement was observed in data completeness in the assessed variables, including patient name, residential address, VL results and TPT start date (Figure 1). Additionally, the system significantly reduced the discrepancy in the number of patients currently on treatment in paper and Data for Accountability, Transparency and Impact (DATIM, the PEPFAR-specific web-based information system for data entry, Data Collection & Analysis) reports. The data reported through DATIM was higher than that reported though EMR-ART, but the difference progressively declined from a baseline of 4,544 in quarter 2 (January-March of 2019) to 405 in quarter 1 (October-December) of 2020. There was no disparity in the count between the two sources during the subsequent quarters.

4 Lessons learned

The implementation of EMR-ART system in Ethiopia created a framework for collecting and analyzing ART data. It provided a platform for data analytics, which should yield long-run gains in health care quality and efficiency. The implementation of EMR-ART and DQI initiative has improved ART data quality and data use, which will have a significant effect on the quality of ART services. It is also currently serving as the sole source of data for ART related reports. The use of innovative online monitoring and mentorship approaches help in monitoring and provision of support in implementing an EMR system. The EMR-ART system improved collaboration between service providers and data personnel. Involvement of various local stakeholders in the establishment and use of the system, and ownership by the host institutions have a positive impact on the utilization and maintenance of the system.



DQI: Data quality and improvement, TPT: Tuberculosis preventive therapy WHO – World Health Organization

Figure 1. Data completeness on selected variables before and after EMR-ART based data quality and use initiative implementation at 111 high HIV client load health facilities in five regions, Ethiopia, April 15, 2018, to September 30, 2020.

Keywords: Electronic medical records, service providers, data quality, information use.

Journal of Health Informatics in Africa

Readiness model for transitioning donor-supported investments in strategic information for health in Kenya: Lessons from implementation in Nakuru and Kakamega counties

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[3] Nakuru County Department of Health

1 Background

The Kenya Health Act 2017emphasizes the need for standardized health information exchange and a comprehensive, functional health information system. There have been considerable investments by National, County health departments and development partners to strengthen Health Information Systems (HIS) around provision of HIS resources, development of indicators and identification of data sources to pave way for effective health data capture, analysis and use. However, most county departments of health are yet to achieve their targets in the areas of (a) leadership coordination and assessment; (b)implementation of HIS strengthening activities and; (c) data management, information products, dissemination and use. Owing to the dwindling donor financing, ensuring sustainability of the digital health solutions becomes a key priority for health sector actors in Kenya. Yet despite this, County Departments of Health (DOH) are at different levels in terms of readiness for transition and sustainability, specifically in financing for digital health systems, structures, and policies to guide implementation of digital health systems and leadership support. This gap highlighted the need to develop interventions to strengthen governance capacity and coordinate the transition for strategic information investments.

2 Methods

The intervention involved development of a Measurement, Learning and Accountability (MLA) transition readiness model with four key components: engagement of county health leadership, assessment of the capacity and commitment levels of the country structures for transition, advocacy and technical assistance in the county budget making process, and joint tracking of transition action plans as part of mutual accountability. The transition readiness assessment tools reviewed five MLA components: leadership and governance, financing, workforce, information management and stakeholders and networking with specific questions that gauged the capacity and commitment levels of the respective county structures. Purposive sampling was used to select the study participants in the two counties with 30 participants selected. The assessment applied focus group discussion using a semi structured questionnaire. The group assessment tool was rolled out in Dec 2019 with a view to build consensus among county staff on the state of various MLA domains. Country-specific results, as well as relevant physical evidence from facility readiness assessments for electronic health records roll out were discussed in plenary sessions with county stakeholders.

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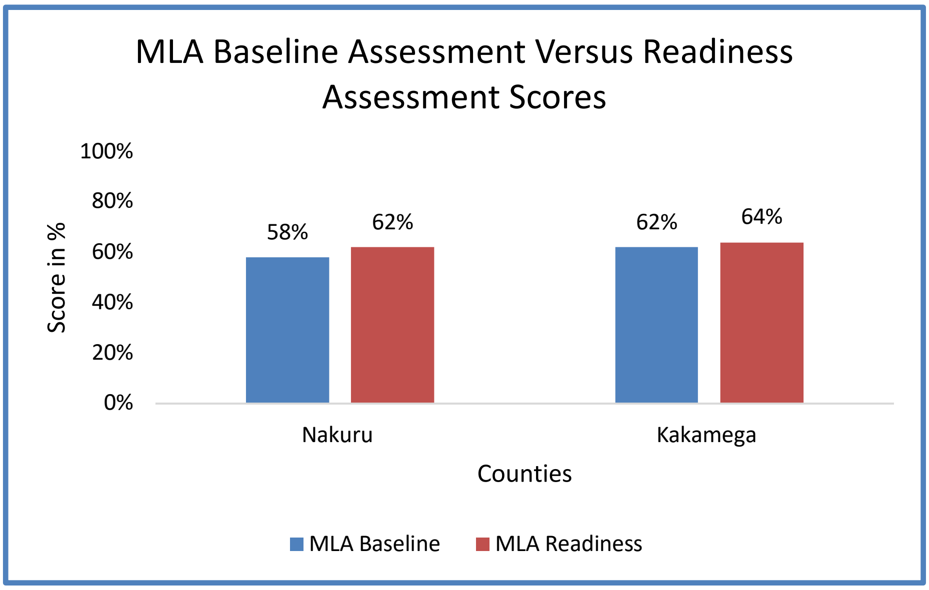
3 Results

The output of the assessment was a MLA transition readiness score, transition action plans and costed MLA plans. The MLA transition readiness score were varied across the counties; Nakuru was at 62% from a baseline of 58% in October 2018 , while Kakamega County was at 64% from a baseline of 62% in March 201 as shown in figure 1 below. The scores are categorized at the emerging level of transition preparedness reflecting available structures and capacity but more efforts need to be focussed on integration and financing. Some of the emerging results from application of a transition readiness assessment tool in Kenya suggest that finances for strategic information and M&E are likely to be committed if policy frameworks protect the allocation. County departments of health should foster partnerships with private sector to support implementation of digital health solutions and engage local institutions of higher learning for technical support for the same. The transition agenda requires high-level engagement, buy-in, and advocacy with a range of actors at subnational and central levels involved in the health sector and decisions on investments in strategic information in health. Counties have costed health information transition and responsibility plans with estimated resource requirements for each of the pillars – governance, capacity, security, hardware, software, reporting and data quality. Counties have coordinating mechanisms for HIS that are led by Governments with transition as a key agenda. Increased allocation for HIS and M&E budgets: Kakamega FY 2019/20 KES 7 Million, FY 2020/21 KES 10 million.

Figure 1. Summary of MLA baseline assessment scores versus MLA transition readiness scores



4 Lessons Learnt and Recommendations

Roll out and scale up of health information systems should be targeted and planned and should consider all components for sustaining HIS. There is need to develop a long-term costed implementation plan with clear responsibility matrix. This will provide information for inclusion into the resource mobilization tools including the annual work plan and the strategic plan. As part of financial sustainability, governments should adopt open source electronics health records systems, as well as endeavour to create a business case to the politicians in order to get resources for scale up. The business case should include the money saved through use of these health information systems, increased quality of service delivery and system visibility. Departments of health should engage and work collaboratively with the County ICT department for HIS roll out. Implementation lessons point to the need for the department to advocate for deployment of full time ICT officers to the department. Roll out of any HIS should start with getting a buy in from the user governments and having them appreciate the advantages brought on board by this system. The engagements for EHR scale up should be broad and target the policy makers within county government and assembly. The National government to prioritize mapping of digital health solutions in all counties to determine status and needs. The County ICT department to recruit and deploy qualified staff to support digital health solutions. Ministry of Health to enforce e-health standards and guidelines. The top county leadership and departments must advocate for interoperability of different systems and frameworks and health solutions.

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Enhanced use of COVID-19 and Health service delivery data in health program management by the County MoH Leadership: A case study of Nakuru, Migori and Kakamega counties in Kenya

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1 Introduction

In Kenya, the emergence of Coronavirus disease (COVID-19) in 2020, necessitated the need for increased capacity in analysis and dissemination of real-time surveillance data to facilitate timely and evidenced based decision making. The emergence of COVID-19 presented a challenge to the Monitoring and Evaluation / Health Information Systems (M&E/HIS) unit officers on how to analyse and present epidemic data in a timely manner for effective epidemic control. In this era, the capacity to utilize digital data analytics and visualization tools is more critical in responding to demand and use of data among decision makers. This abstract aims to shade light on how increased capacity in use of digital and visualization tools is valuable in decision making process. Specifically, it highlights the importance of building capacity of M&E/HIS unit officers in data analysis and visualization with the aim of strengthening evidenced-based program management and planning.

2 Interventions

To enhance the use of COVID-19 data in response to COVID-19 pandemic on real-time basis, United States Agency for International Development (USAID Tupime Kaunti provided Technical Assistance to county health Management Team to strengthen capacity of the county M&E/HIS unit and surveillance teams in data analytic. In addition, the project mentored the surveillance and data management sub committees to generate daily situation report (SITREP). To facilitate the use of COVID-19 data by the response committees, the project conducted a four-day training on Quantum Geographic Information System (QGIS) and dashboard development using the PowerBI. The training on GIS encompassed introduction to GIS and its uses in Health, geocoding of COVID-19 patient data, ethical considerations in population mapping, intermediate excel analysis, network analysis using hub and spoke dispersion models, hotspot mapping, developing simple dashboards and infographics for real-time visualization using Power-BI.

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Table 1. Staff trained in QGIS and Power-BI

COUNTY	QGIS			POWER-BI		
	Male	Female	Total	Male	Female	Total
KAKAMEGA	4 (40%)	6 (60%)	10 (100%)	4 (40%)	6 (60%)	10 (100%)
NAKURU	6 (100%)	0 (0%)	6 (100%)	0 (0%)	5 (100%)	5 (100%)
MIGORI	4 (50%)	4 (50%)	8 (100%)	4 (50%)	4 (50%)	8 (100%)
TOTAL	14 (58%)	10 (42%)	24 (100%)	8 (35%)	15 (65%)	23 (100%)

Data source: Tupime Kaunti training database

The objective of Power BI training was to enhance availability of data through real-time data analysis and visualization of health indicators including COVID-19 data using interactive dashboards. The ToTs were followed up with one-on-one mentorship by the project's County Planning and Learning specialists until they were competent in developing GIS maps and PowerBI dashboards.

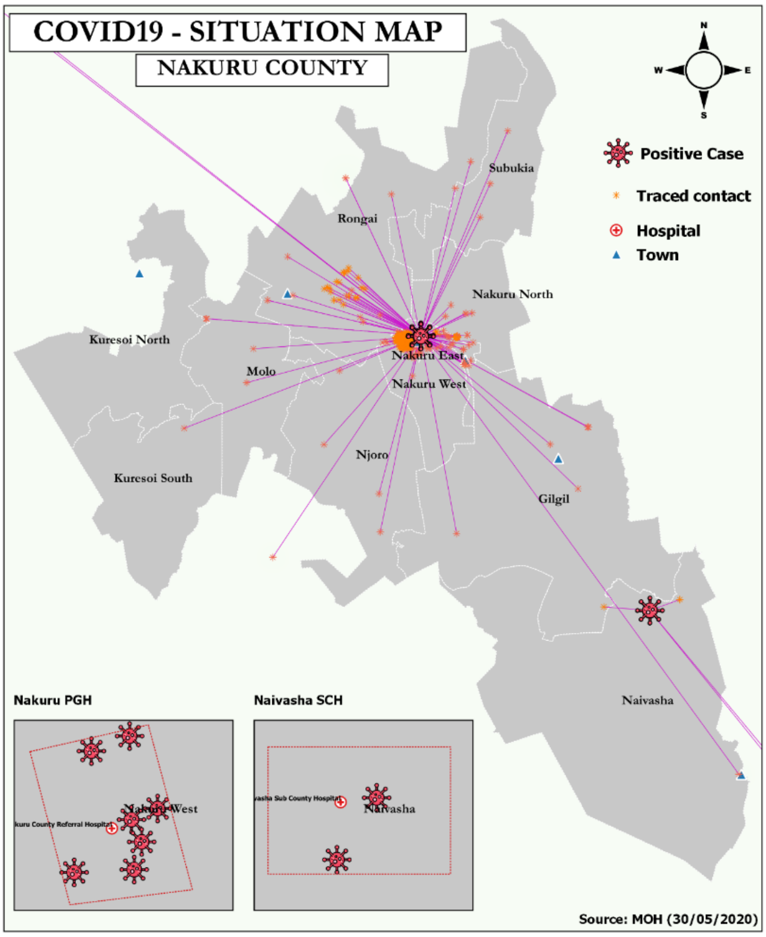
3 Results

The GIS maps and dashboard developed by the county data analytics ToTs were shared with the county COVID -19 response committees and the county leadership (CoH and ECM) for evidence-based emergency response. Specifically, the use of GIS maps to visualize COVID-19 data in Migori, Nakuru, and Kakamega counties was critical in informing the county RRT teams on the COVID19 hotspots so as to strategically intensify prevention measures in targeted locations. The trained county M&E/HIS unit officers took lead in analysis and dissemination of routine data on a daily and weekly and monthly basis.

3.1 Nakuru case study

In Nakuru county, the COVID-19 maps highlighted positive cases together with the traced contacts. This showed the density of the COVID-19 cases and the likelihood of having a resurgence of COVID-19 cases. This gave the rapid response team information that was critical in mapping hotspots and communicating the same to the population. This information was used in informing the county RRT teams on the COVID19 hotspots who strategically intensified prevention measures in targeted locations. The datasets used included County line-list COVID-19 data and select reproductive health, and HIV cascade data. From the trainings the teams generated COVID19 factsheets that were disseminated during Rapid Response Teams and CHMT meetings.

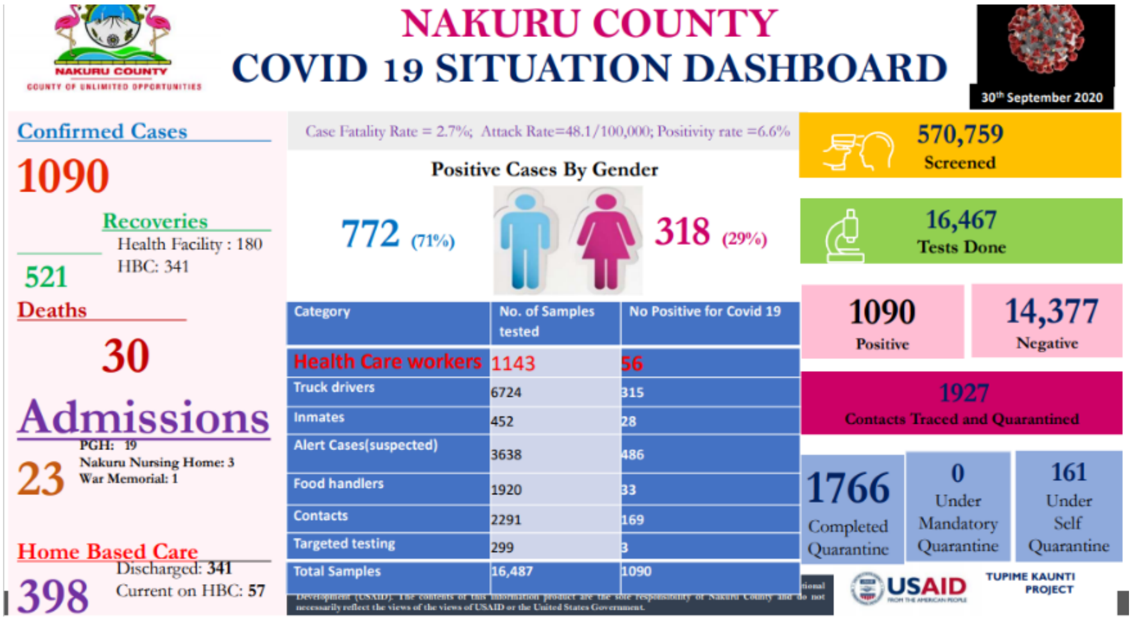
Figure 1: COVID-19 Situation Map



Data Source: COVID-19 dataset

Nakuru county factsheet was further shared with the Governor on a weekly basis for use in implementing targeted interventions to combat the epidemic. The County Executive Committee Member for health utilized the factsheet during an interview conducted in NakuTV to sensitize the community on COVID19 prevention measures. The RRT county team used the factsheet to inform conversion of Bondeni maternity to COVID-19 isolation centre due to rising cases of COVID-19 in Nakuru East Sub-County, the start of home-based care in Nakuru East, Nakuru west and Naivasha sub counties as well as the training of health care workers from private facilities on Infection Prevention and Control (IPC).

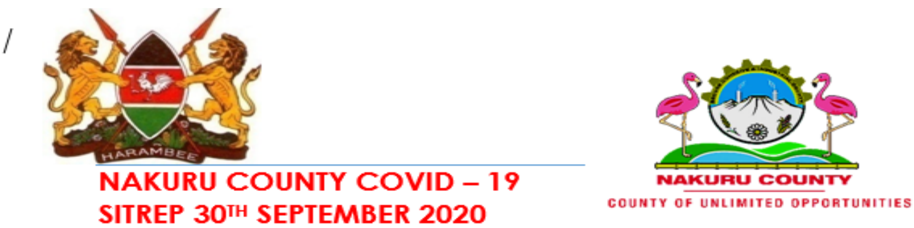
Figure 2. Nakuru county Sample COVID-19 Factsheet



Data source: Nakuru County COVID-19 database

The county M&E/HIS unit and Surveillance teams further generated daily and weekly Situation Reports (SITREPs) that were shared with the county Rapid response teams and the county government for use in decision making. The reports detailed the positive cases, sample positivity rates, case fatality rate, attack rates and case distribution by age, sex, locality, and sex among others. The technical assistance spanned analysis, presentation, and packaging of the SITREP reports. The county data analytics ToTs spearheaded development of the data analysis whereas the RRT team members were pivotal in interpretation of the analyzed data.

Figure 3. Nakuru county Sample SITREP Report



NAKURU COUNTY COVID – 19
SITREP 30TH SEPTEMBER 2020

NAKURU COUNTY
COUNTY OF UNLIMITED OPPORTUNITIES

Surveillance

- A total of 16,467 persons have been tested. These include contacts to the confirmed cases.
- Cumulative number of confirmed cases are 1090
- Attack rate is 48.1/100,000 population
- Case fatality rate is 2.7%
- Overall Positivity rate is 6.6%.
- 521 have Recovered (180 health facility and 341 HBIC)
- Admissions 23:– 19 in Nakuru PGH, 3 in Nakuru Nursing Home, 1 in Nakuru War memorial. 11 cases are on supplemental oxygen
- There were 24 new cases in the past 24 hours from 90 samples tested in the same period giving a positivity rate of 26.6%
- 398 cases have undergone through home based care, 341 discharged after they recovered and 57 still on care.
- Other cases were traced to other counties and were managed/are being managed there

Distribution of test samples collected per category

Data source: Nakuru County COVID-19 SITREP Sep 30th 2020

As part of COVID-19 response, the RRT further utilized the information to conduct fumigation in the schools after reporting emergence of COVID-19 cases among students in four high schools. At the end of the December 2020, 39 students had turned positive to COVID-19 and all the cases had been isolated, treated and discharged. The department of health continued engagement with the Ministry of Education to map schools to inform the COVID-19 response preparations ahead of schools opening in January 2021. Using the data, the county RRT recommended closure of Bondeni health facility as a COVID-19 centre as the cases had reduced to less than ten. The analysis of COVID-19 cases in Nakuru further showed an increase of health care workers testing positive despite the availability of Personal Protective Equipment (PPEs) and the training on COVID-19 prevention measures. The committee utilized the information to inform assessments and interventions to prevent further infection among the health care workers. Some of the interventions implemented were training of healthcare workers on proper use of PPEs and banning of social eating within the health facilities.

3.2 Migori County Case Study

In Migori county, the trained staff from the M&E/HIS and Surveillance unit officers disseminated and facilitated review of the impact of COVID-19 on other essential medical services. Sample analysis of service delivery data showed a drop in performance between Jan to Mar 2020 in; outpatient utilization rate that dropped from 22% to 9% and first antenatal visit coverage dropped from 70% to 65%. Key actions such as introduction of curfew cards were recommended and implemented to address the gaps. Notably in May 2020, there were improvement such as; new antenatal visit improved from 79% in March to 90% in May; and the percentage of pregnant women attending ANC who received iron/folate supplements, which had been affected by commodity stock-out, improved from 26% in March to 75% in May.

3.3 Kakamega County Case Study

Kakamega county generated and disseminated the COVID19 situation reports (SITREP) and factsheets during the county multi-sectoral committee, County, and sub-county RRT. In November 2020, it was noted that out of 458 cases reported, 99 (23%) were Health Care workers. The most affected health facilities were Navakholo and Matungu Sub-county hospitals that were later targeted for fumigation and review of Infection Prevention and Control (IPC) measures. Using the data, the county decided to have Mumias West health facility to manage HCW testing positive for COVID-19 as Likuyani health facility managed the other cases. Kakamega PGH was set aside to manage critical COVID-19 cases.

4 Conclusion

Provision of timely data is critical in ensuring the leadership effectively respond to issues hindering attainment of the set objectives. Visualization of data and information using innovative open-source tools like QGIS maps and PowerBI enhances the quality of data analysed and presented for decision making. Thus, to respond to an epidemic requires that a county has the capacity to strategically deliver on ensuring high quality data is analysed, presented, interpreted and used in combating the effects and impacts of the disease.

Keywords: Geospatial Information System; dashboard; decision support; visualization; maps; PowerBI; COVID-19;

Leveraging Digital Health Interventions to Enhance Prevention, Response and Control of Public Health Emergencies in Low and Middle-Income Countries

ISBN: 978-3-948681-01-2

Publisher
Koegni eHealth, Innovation for Development e.V. Germany
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D-22372 Hamburg, Germany

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