Clinical Data Flow in Botswana Clinics: Protocol for a Mixed-Methods Assessment

Grey Faulkenberry, Audrey Masizana, Badisa Mosesane, Kagiso Ndlovu

Submitted to: JMIR Research Protocols
on: October 24, 2023

Table of Contents

Clinical Data Flow in Botswana Clinics: Protocol for a Mixed-Methods Assessment

Grey Faulkenberry[1*] BS, MPH, MD; Audrey Masizana[2*] PhD; Badisa Mosesane[3*] BSc; Kagiso Ndlovu[4] PhD

[1]Department of Biomedical and Health Informatics Children's Hospital of Philadelphia Philadelphia US
[2]eHealth Research Unit Department of Computer Science University of Botswana Gaborone BW
[3]Global Health Informatics Children's Hospital of Philadelphia Gaborone BW
[4]Informatics Division Sir Ketumile Masire Teaching Hospital Gaborone BW
[*]these authors contributed equally

Corresponding Author:
Grey Faulkenberry BS, MPH, MD
Department of Biomedical and Health Informatics
Children's Hospital of Philadelphia
Roberts Center for Pediatric Research
734 Schuylkill Ave, 2716 South Street
Philadelphia
US

Abstract

Background: Botswana has made significant investments in its healthcare information infrastructure, including vertical programs for child health and nutrition, HIV care, and Tuberculosis (TB). However, effectively integrating the more than 18 systems in place for data collection and reporting has proved to be challenging. The Botswana Health Data Collaborative Roadmap Strategy (2020-24) states that “there exists parallel reporting systems and data is not integrated into the mainstream reports at the national level,”seconded by the Botswana National eLearning strategy (2020) stating that “there is inadequate information flow at all levels, proliferation of systems, reporting tools are not synthesized; hence too many systems are not communicating.”

Objective: 1. Create a visual representation of how data is processed and the inputs and outputs through each healthcare system level.
2. Understand how front-line workers perceive healthcare data sharing across existing platforms and the impact of data on healthcare service delivery.

Methods: The approach engaged participants from the start, allowing input about all aspects of the study. Ethical clearance was obtained from all necessary stakeholders, and over 30 institutions were sensitized. The Rapid Assessment Process (RAP) and Technology Assessment Model for Resource Limited Settings (TAM-RLS) informed the design of survey questionnaires.

Results: The steps taken to perform our study so far have broader value and applicability. These steps should be adopted by most research studies in the healthcare sector and are especially important in environments where it may be difficult to secure buy-in regarding participation.

During this process, local healthcare centers commented that they required further data science education. To this end, we created a free data science workshop to teach basic skills to those working in the healthcare sector. As part of this workshop, we invited the participants to help us collect further data about Botswana’s data healthcare infrastructure as phase two of our project to try and broaden and deepen our understanding.

Conclusions: We believe the steps we have detailed and implemented for our study should be considered heavily when designing global health informatics studies. Even more broadly, global health research in general would benefit from including much of our approach, especially in environments where it may be difficult for buy-in regarding participation.

(JMIR Preprints 24/10/2023:52411)
DOI: https://doi.org/10.2196/preprints.52411

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Paper Type: Protocol

Title: Clinical Data Flow in Botswana Clinics: Protocol for a Mixed-Methods Assessment

Author Names and Affiliations:

J Grey Faulkenberry, MD MPH
Department of Biomedical and Health Informatics
Children's Hospital of Philadelphia
CHOP Roberts Center for Pediatric Research
Corresponding Author:
734 Schuylkill Ave, Philadelphia, PA 19146, USA
faulkenbej@chop.edu
1.215.439.3265

Badisa Mosesane, BSc
eHealth Research Unit and CHOP Global Health Informatics
University of Botswana
Gaborone, Botswana

Audrey Masizana, PhD
eHealth Research Unit and Computer Science
University of Botswana
Gaborone, Botswana

Kagiso Ndlovu, PhD
Informatics Division
Sir Ketumile Masire Teaching Hospital
Gaborone, Botswana

Keywords:

1. Global Health
2. Health Information Systems
3. Electronic Healthcare Records (EHRs)
4. Interoperability
5. Data Flow

ABSTRACT

Background: Botswana has made significant investments in its healthcare information infrastructure, including vertical programs for child health and nutrition, HIV care, and Tuberculosis (TB). However, effectively integrating the more than 18 systems in place for data collection and reporting has proved to be challenging. The Botswana Health Data Collaborative Roadmap Strategy (2020-24) states that "there exists parallel reporting systems and data is not integrated into the mainstream reports at the national level," seconded by the Botswana National eLearning strategy (2020) stating that "there is inadequate information flow at all levels, proliferation of systems, reporting tools are not synthesized; hence too many systems are not communicating."

Objectives: 1. Create a visual representation of how data is processed and the inputs and outputs through each healthcare system level. 2. Understand how front-line workers perceive healthcare data sharing across existing platforms and the impact of data on healthcare service delivery.

Methods: The setting included a varied range over 30 healthcare facilities across Botswana, aiming to capture insights from multiple perspectives into data flow and system integration challenges. The study design combined qualitative and quantitative methodologies, informed by the Rapid Assessment Process (RAP) and the Technology Assessment Model for Resource Limited Settings (TAM-RLS). The study employed a participatory research approach to ensure comprehensive stakeholder engagement from its inception. Survey instruments were designed to capture the intricacies of data processing, sharing, and integration among healthcare workers. A purposive sampling strategy was employed to ensure a wide representation of participants across different healthcare roles and settings. Data collection utilized both online surveys and in-depth interviews. Preliminary themes for analysis include perception of the value of healthcare data and experiences in data collection and sharing. Ethical approvals were comprehensively obtained, reflecting the commitment to uphold research integrity and participant welfare throughout the study.

Results: The study recruited almost 44 healthcare facilities, spanning a variety of healthcare facilities. Of the 44 recruited facilities, 27 responded to the surveys and participated in the interviews. 75% of healthcare professionals participating came from clinics, 20% from hospitals, and 5% from health posts and mobile clinics. As of October 10, 2023 the study had collected over 200 quantitative surveys, and conducted 90 semi-structured interviews.

Conclusions: This study has so far shown enthusiastic engagement from the healthcare community, underscoring the relevance and necessity of this study's objectives. We believe the methodology, centering around extensive community engagement, is pivotal in capturing a nuanced understanding of the healthcare data ecosystem. The focus will now shift to the analysis phase of the study, with the aim of developing comprehensive recommendations for improving data flow within Botswana's healthcare system.

INTRODUCTION

Over 2500 years ago, Hippocrates argued it was important to keep a record of a patient's conditions and symptoms [1,2]. While we have developed new ways of record keeping, accurate and timely record keeping remains as important, if not more so, given the interconnectedness of communities. The World Health Organization has further emphasized the importance of electronic health records towards the achievement of Universal Health Coverage and health-related Sustainable Development Goals (SDGs)[3]. In the US and other high-income countries, Electronic Health Records (EHRs) capture 90%+ of this data. However, in low- and middle-income countries, the percentage is much smaller but steadily increasing. Despite the documented benefits of EHRs, a number of concerns have been raised. The aim of this study is to assess the flow of clinical data through various systems(EHRs and EMRs) by understanding and describing the flow of clinical data. In addition, the study explores the perceptions of healthcare workers regarding healthcare data collection, sharing and use across Botswana's healthcare facilities.

Data Generators

Data is often collected using multiple separate systems and reported in aggregate at a system or national level, with varying benefits seen by the front-line clinicians [4]. This is more than simply an aggravation. Ensuring that front-line clinicians have proper access to data could improve clinical outcomes on a wide range of issues, from the correct treatment of pediatric malaria [5], to decreasing medication errors in Tuberculosis treatment and even reducing patient wait times in clinics [6].

From the systems perspective, lack of access to data, concerns about data validity and accuracy, perceived uselessness of data collection, and an inability to transfer information are continually ranked among the leading barriers to effectively implementing EHRs by clinical staff, administrators, medical directors, and Information Technology personnel [7,8]. A study conducted in South Africa [9] emphasized that data routinely collected at healthcare facilities and submitted to district offices are commonly unreliable. The study investigators further asserted that 'data validation was limited' and 'little analysis of data occurred' at the participating facilities sampled in their study, leading to a gloomy picture overall. However, even if analysis tools were improved, with multiple systems in use, they would only be applicable to a small subset of all the data collected. Another study on the Prevention of Mother to Child Transmission of HIV (PMTCT) in South Africa [10] adds that there are major gaps in both completeness and accuracy in the collection and reporting of data that tracks service delivery.

Given these concerns, it is crucial to understand the views of those inputting and generating this data. As one study found, "data quality issues are not a result of the type of record, but the attitude of the person inputting the data" [11].

Interoperability

What is desired is to integrate organizational information systems, devices, and applications to access, exchange, and cooperatively use data across organizations. This would provide a platform where systems with different infrastructures could share data and services and hence would have the same expectations for the contents, context, and meaning of the data. To advance health information system interactions, there must be interoperability ("the ability of two or more systems or components to exchange information and to use the information that has been exchanged" [12]). Improved interoperability would result in a decrease in missing data as systems fill in each other's gaps and alleviate some of the clerical burden inherent in using multiple systems. Consequently, there would be improved health data quality [13]. Interoperability is often guided by an interoperability framework, offering an agreed approach for multiple organizations to achieve

interoperability towards the joint delivery of services.

Botswana supports non-interoperable diverse health information systems [14], and currently has more than 18 systems in place for data collection and reporting. A 2019 UNICEF report on Botswana highlights these points [15], making note of the different data tracking systems that "are not necessarily coordinated or reliable across health facility levels and systems." For example, UNICEF highlights Botswana's strong HIV early infant diagnosis program but notes the long turnaround times for results and lack of HIV-exposed infants' final infection status. The report further states, "Key PMTCT variables have poor quality data thought to be associated with lack of understanding of the required data and lack of uniformity in recording and reporting" [15]. One of the key recommendations of this report was to "look for opportunities to simplify, harmonize, reduce redundancy and roll out the most reliable systems to all districts and health facilities."

In response, the Botswana Ministry of Health (MOH) released the Botswana Health Data Collaborative Roadmap Strategy (2020-24) [16], which noted that "there exists parallel reporting systems and data is not integrated into the mainstream reports at the national level", seconded by the Botswana National eLearning strategy (2020) [17] stating that "there is inadequate information flow at all levels, proliferation of systems, reporting tools are not synthesized; hence too many systems are not communicating."

Objectives

This study was driven by two primary goals to align with the Ministry of Health's objectives of enhancing data collection, data sharing, reporting and utilization.

1. Create a Visual Representation of Data Flow within the Healthcare ecosystem of Botswana.
2. Gain insights into how frontline workers perceive the collection, use, and sharing of data with the healthcare sector.

A Data Flow Diagram (DFD) would encompass the entire data journey, starting from data generation by the frontline clinician and tracking it through various stages, including data transfers, reporting, administrative processes, laboratory operations, government involvement, and, where applicable, returning it to frontline workers who generated it. By visualizing this data flow, the study intends to offer insights into how data informs operations at different levels and highlight the exchange of information among people, processes, and system components. Describing and understanding this flow, along with relevant system protocols and boundaries, is crucial for improving decision-making and strategic planning within an organization. Poor data flow could lead to incompatible and inconsistent data systems, resulting in information silos. Conversely, if data linkages are properly established, there is potential to enhance data access and sharing, ultimately leading to valuable insights that exceed the sum of isolated data sources.

Understanding the perceptions of front-line healthcare workers is essential, particularly in the context of potential system integration and workflow changes. Frontline workers' attitudes towards data collection directly impacts how it is used as well as its quality.[11] This goal aims to assess how healthcare data is currently accessed, transferred, used, and reported by workers, as well as whether they recognize value in these processes.

METHODS

Setting and Community Engagement

This study commenced to engage healthcare facilities across the country with an attempt to engage facilities as widely as possible at each district. The purpose of the sensitizations was to introduce the study, secure buy in, and increase participation of healthcare workers at each site.

The approach to engaging healthcare facilities involved direct contact with their leadership. The study team reached out through phone calls and formal email invitations, followed by virtual and onsite sensitization meetings and workshops. Over 70 emails were sent out to healthcare facilities to arrange their involvement in the study, and close to hundred (100) phone calls were made to engage facilities' leadership to coordinate participants' involvement in the study. These sessions played a crucial role in gaining the facilities' buy-in and motivating their healthcare workers to participate.To encourage maximum participation and inclusivity, we embraced an open community research approach. Our target population consisted of healthcare professionals who were directly involved in data collection, data sharing, and data-driven decision-making or utilized information and communications technology systems for healthcare tasks. Healthcare workers' daily experience in data-related tasks made them invaluable contributors to this study. The study team emphasized clinicians' role as collaborators in the project, underlining the significance of their input in shaping the research instruments. This approach resulted in the refinement of questions in the REDCap survey instruments and the inclusion of new ones, ultimately leading to more insightful responses.

Study Design

This study adopts a mixed-methods approach to assess the flow of clinical data across Botswana's healthcare facilities. The design of the study encompassed both qualitative and quantitative methods to gain a comprehensive understanding of how healthcare data is collected, shared and used in the selected facilities. The surveys were informed by the Rapid Assessment Process (RAP) [18–20] model and the Technology Acceptance Model for Resource Limited Settings (TAM-RLS) [21,22], ensuring they were both comprehensive and contextually relevant.

Survey Instruments

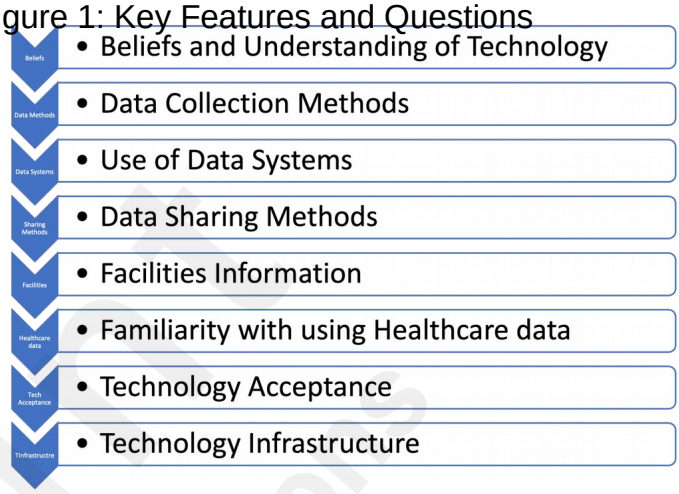
Our data collection instruments were developed to align with the study's objectives and to ensure that we could capture a comprehensive view of the healthcare data flow in Botswana's healthcare system. During the development, we discovered a notable gap in existing literature. Previous assessments of e-health readiness and maturity have used various frameworks [23–26] that assess dimensions such as core need readiness, technological readiness, and learning readiness. The MEASURE Evaluation [27] framework emerged as the only assessment we found that documents the flow of clinical data from the patient to the clinician, to the labs or government, and ultimately back to the clinician and patient. Visual representations were essential for enhancing our comprehension, given their widespread use across various healthcare specialties and industries [28,29].

This resulted in a two-pronged survey approach. The first was a self-led quantitative online survey used to broadly understand how clinicians collect data and share it. This method focused on the demographics of the participants, the electronic systems used, data collection mechanisms, frequency in reporting and usage of the collected healthcare data.

The qualitative component of this study involved a semi-structured interview method, allowing the participants to offer detailed perceptions on the use of technology and data management practices within healthcare settings in Botswana. These interviews, conducted by research assistants, were

informed by the study's objectives and relevant literature, focusing on healthcare workers' perspectives on collecting and managing healthcare data and service delivery. Participants, including administrators, nurses, and doctors with various roles in the healthcare sector, were encouraged to provide in-depth insights into both manual and digital data collection methods, along with their views on data sharing and usage in Botswana. The aim was to elicit comprehensive information and opinions regarding the flow of clinical data, focusing on key features and critical questions outlined in Figure 1.

Figure 1: Key Features and Questions



Sampling

Purposive sampling was employed to select participants who interacted with healthcare data representing various levels of the healthcare system, including general nurses, monitoring and evaluation officers, healthcare administrators, frontline clinicians and IT professionals. All participants were invited to participate in the two surveys of this study.

Selection Criteria and Representation

We strategically chose healthcare facilities located at three locations in Botswana: Gaborone, Maun, and Selebi Phikwe. Each of these facilities and their surrounding areas represent a distinct region of the country. This choice allowed us to capture diverse perspectives, reflecting the varied healthcare environments within the country. Ethical approval at the facility level was a paramount prerequisite before the study commenced, with key contacts typically residing within the Institutional Review Board (IRB) chairmanship.

Data Collection

The RedCap (Research Electronic Data Capture) system together with interviews were utilized to collect data from study participants. The surveys were distributed electronically to a representative sample of healthcare workers across different healthcare facilities in Botswana. A comprehensive list was compiled for all of the large, public healthcare facilities in the country, leading to invitations being extended to over 30 healthcare facilities, encompassing both comprehensive public hospitals and clinics. Out of these, 23 sites expressed interest in the study and actively participated in the study, with full engagement in sensitization and data collection workshops. About 15 sensitization sessions were held to inform and engage healthcare facility leadership and health workers about the study's objectives, methods, potential impacts and obtain feedback. Of the 15, four (4) were held in-person while eleven (11) were held virtually via Microsoft Teams led by the study team research assistants at the University of Botswana.

A total of 157 responses were collected from the first survey while the second survey had 227 responses.

Data Analysis

Data from the quantitative survey will be analyzed using descriptive statistical methods to examine trends, correlations and associations related to healthcare data sharing and utilization at hospitals and

clinics.

We plan to employ thematic analysis to analyze the qualitative results of the study, mainly to identify recurring themes, patterns and insights from the qualitative data provided by the study participants. The analysis will begin with focusing on themes such as perception of the value of healthcare data, experiences of data collection and sharing, and the adoption and familiarity of different technological solutions.

Findings from both the qualitative and quantitative data collection will be integrated to provide a comprehensive understanding of the flow of clinical data across the sampled facilities. Data integration will involve comparing and contrasting qualitative themes with quantitative survey results to validate and complement findings.

For analysis purposes, tools including Jupyter notebooks and NVivo software will be utilized to pre-process the data and develop code for analyzing data coming from the participating healthcare workers.

Ethical Approvals

Before starting this study, we ensured we had all appropriate permissions from the Institutional Review Boards (IRBs) at the University of Botswana (UB) - Protocol/Reference Number UBR/RES/IRB/BIO/258, the Human Research Development Committee (HRDC) in Botswana, the University of Pennsylvania (UPenn) - Protocol Number 849993, and Children's Hospital of Philadelphia (CHOP) - Protocol Number 22-019994, in addition to letters of support from the MOH and the local institutions with which we were working. Additionally, ethical approval was obtained at the health facility level through IRB approval and review.

Adapting to COVID-19 Restrictions

Acknowledging the constraints imposed by the COVID-19 pandemic, this study was adapted to ensure safety without compromising engagement. Most sensitization sessions and all interviews were conducted remotely, utilizing video conferencing tools to maintain interactive and personal communication channels.

RESULTS

This study recruited close to 44 healthcare facilities, including district hospitals, public referral hospitals, primary healthcare clinics, mobile health clinics and health posts. Out of the 44 recruited facilities, 27 responded to our surveys and interviews. About 75% of the healthcare professionals that participated in the study were coming from clinics, 20% from hospitals while 5% were from health posts and mobile clinics. Our results indicate that two essential factors are crucial in participation in our assessment. Firstly, sensitization meetings followed by stakeholder engagement workshops with participants. Secondly, establishing an open and collaborative environment and treating participants as experts and key stakeholders in the project to ensure their inputs and suggestions are valued and incorporated into the study.

The steps taken in order to perform our study so far have broader value. These steps should be adopted by most research studies in the healthcare sector and are especially important in environments where it may be difficult for buy-in regarding participation.

During this process, local healthcare centers commented that they required further data science

education. To this end, we created a free data science workshop to teach basic skills to those working in the healthcare sector. As part of this workshop, we invited the participants to help us collect further data about Botswana's data healthcare infrastructure as phase two of our project to try and broaden and deepen our understanding.

The data collection process commenced June 2022 and is projected to end December 2023. Data was collected virtually using REDCap forms, and interviews were conducted via Zoom and Microsoft Teams and then transcribed into the REDCap system. Out of the 30 facilities enrolled in the study, as of October 24, 2023 we have collected 200 records for the initial survey and captured 90 records for the semi-structured interviews.

DISCUSSION

This research project aims to systematically map the data flow within Botswana's healthcare infrastructure and to delve into healthcare workers' perspectives on data sharing practices. Using a series of sensitization meetings the study effectively engaged the community, making them aware of the project, and eliciting feedback for the project itself. The enthusiastic engagement from the healthcare community underscored the relevance and necessity of the study's objectives. The use of virtual tools (such as Redcap forms) for data collection demonstrate adaptability to modern technologies, which can enhance efficiency on remote data collection, especially in the context of global events like the COVID-19 pandemic. As of October 24, 2023 over200 records were collected for the initial survey and 90 records were captured for the semi-structured interviews from 30 facilities around the country.

Given the response and enthusiasm to the study, it would seem to suggest both that the healthcare community appreciates why this project is important, and also that engaging the community early and fostering collaboration and transparency encourages more active participation. This approach was instrumental in building trust and a sense of ownership among participants, qualities that are often overlooked yet critical for the success of such endeavors. The preliminary results do seem to indicate that the study was successful in engaging a wide range of healthcare professionals involved in the day-to-day management and utilization of healthcare data.The insights derived will help identify bottlenecks in data flow and opportunities for enhancing interoperability among the myriad of healthcare information systems currently in use.

The study highlights the significance of engaging stakeholders in the healthcare sector, including healthcare professionals from various types of facilities. Sensitization meetings and workshops were found to be crucial in encouraging participation and ensuring insights and perspectives of participants were valued. This emphasizes the importance of collaboration and inclusive decision-making processes in healthcare research. The finding that stakeholder engagement and participation are critical for the success of healthcare research aligns with previously published works. A growing body of literature in global health has emphasizes the importance of involving stakeholders, including healthcare professionals in all stages of research to enhance relevance, ownership, sustainability, and uphold ethical standards [30–33]. Although no studies specifically evaluating participatory research in global health informatics were found, this study would seem to suggest that these principles observed in a broader global health context appear to be applicable.

There are a number of limitations that should be taken into account. from a wide range of healthcare professionals, but with this kind of a study, a larger cross-section of the healthcare workers would improve the generalizability of the findings. In addition, the study relied on self-reported data, which may introduce response bias. Interviews conducted and recorded by research assistants could have

inconsistencies due to variations in data capturing or missing nuanced information from participants. Future research could benefit from a larger sample size, more varied healthcare facilities, audio recording and later transcribing all of the interviews, and direct observation at healthcare facilities.

As we move forward, the focus will shift towards a more in-depth analysis of the data collected, with the aim of developing comprehensive recommendations for improving data flow within Botswana's healthcare system. The anticipated second manuscript will detail these findings and recommendations, providing more concrete guidance for Botswana's continued digitization of its healthcare system. By documenting and sharing the methodology and initial steps of our study, this research aims to provide a blueprint for similar research endeavors, emphasizing the importance of community engagement and methodological rigor. This approach will not only inform healthcare policy but also contribute to more effective and integrated healthcare practices.

Acknowledgements

We have a number of groups to thank, without whom this work would not have been possible. We would like to thank our research assistants Game Nunu Maabane, Marang Setsoma, Ngaka Morake, Onneile Kamogelo Joseph, Ruth Gaopelo, and Thato Ntsholetsang; Katherine Kellom, Diya Nag, and Lanelle Quzack for their work with our qualitative analysis and write-up; the CHOP Global Health Informatics Program, notably Tony Luberti, Sansanee Craig, and Hannah Bocchinfuso for their support, input, and edits to the manuscript; the ongoing support and encouragement from the University of Botswana, the Children's Hospital of Philadelphia and the University of Pennsylvania. Lastly, our profound thanks to the Botswana Ministry of Health and all the healthcare facilities that participated in this study.

Contributions

Grey Faulkenberry - conceptualization, data curation, formal analysis, funding acquisition, methodology, writing original draft.
Audrey Masizana - conceptualization, funding acquisition, methodology, writing original draft, project administration, supervision.
Badisa Mosesane - data curation, methodology, investigation, project administration, writing original draft.
Kagiso Ndlovu - conceptualization, funding acquisition, methodology supervision, writing original draft.

Data Sharing

Data analysis is ongoing as of October 24, 2023. We will address data sharing in our planned future manuscript to include a complete analysis of the data.

Competing Interests

Grey Faulkenberry is the CTO of MayJuun.

Funding

This research was funded by a Pilot Grant from the Children's Hospital of Philadelphia Global Health Center.

REFERENCES

1. Chrysopoulos P. Hippocrates: The Greek Father of Modern Medicine | GreekReporter.com. Accessed August 18, 2020. https://greece.greekreporter.com/2020/05/26/hippocrates-the-greek-father-of-modern-medicine/

2. Hippocrates. History Learning Site. Accessed August 18, 2020. https://www.historylearningsite.co.uk/a-history-of-medicine/hippocrates/
3. Universal health coverage (UHC). Accessed September 9, 2023. https://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-(uhc)
4. Dixon BE, Pina J, Kharrazi H, Gharghabi F, Richards J. What's Past is Prologue: A Scoping Review of Recent Public Health and Global Health Informatics Literature. *Online J Public Health Inform*. 2015;7(2):e216. doi:10.5210/ojphi.v7i2.5931
5. Agarwal S, Perry HB, Long LA, Labrique AB. Evidence on feasibility and effective use of mHealth strategies by frontline health workers in developing countries: systematic review. *Trop Med Int Health*. 2015;20(8):1003-1014. doi:10.1111/tmi.12525
6. Fraser HSF, Biondich P, Moodley D, Choi S, Mamlin BW, Szolovits P. Implementing electronic medical record systems in developing countries. *Inform Prim Care*. 2005;13(2):83-95.
7. Kruse CS, Kothman K, Anerobi K, Abanaka L. Adoption Factors of the Electronic Health Record: A Systematic Review. *JMIR Med Inform*. 2016;4(2):e19. doi:10.2196/medinform.5525
8. Akhlaq A, McKinstry B, Muhammad KB, Sheikh A. Barriers and facilitators to health information exchange in low- and middle-income country settings: a systematic review. *Health Policy Plan*. 2016;31(9):1310-1325. doi:10.1093/heapol/czw056
9. Garrib A, Stoops N, McKenzie A, et al. An evaluation of the District Health Information System in rural South Africa. *South Afr Med J Suid-Afr Tydskr Vir Geneeskd*. 2008;98(7):549-552.
10. Mate KS, Bennett B, Mphatswe W, Barker P, Rollins N. Challenges for routine health system data management in a large public programme to prevent mother-to-child HIV transmission in South Africa. *PloS One*. 2009;4(5):e5483. doi:10.1371/journal.pone.0005483
11. Charnock V. Electronic healthcare records and data quality. *Health Inf Libr J*. 2019;36(1):91-95. doi:10.1111/hir.12249
12. Geraci A. *IEEE Standard Computer Dictionary: Compilation of IEEE Standard Computer Glossaries*. IEEE Press; 1991.
13. Reisman M. EHRs: The Challenge of Making Electronic Data Usable and Interoperable. *Pharm Ther*. 2017;42(9):572-575.
14. Ndlovu K, Scott RE, Mars M. Interoperability opportunities and challenges in linking mhealth applications and eRecord systems: Botswana as an exemplar. *BMC Med Inform Decis Mak*. 2021;21(1):246. doi:10.1186/s12911-021-01606-7
15. Dr Bigirimana, Francoiose, Dr Nuwagira, Innocent, Dr Shaffer, Nathan, et al. *Technical Support on Data Quality Improvement for the Botswana PMTCT Programme in Line with Requirements of Validation of EMTCT for HIV and Syphilis*. UNICEF; 2019:16.
16. Kwape DL. Botswana Health Data Collaborative Roadmap Report (2020 -2024).
17. Kwape, Lemogang. The eHealth Strategy of Botswana (2020-2024). Published online March 10, 2020. Accessed May 4, 2023. https://ehealth.ub.bw/bhdc/Docs/MOH%20ehealth%20Strategy%20Book%20A4.pdf
18. Vedanthan R, Blank E, Tuikong N, et al. Usability and Feasibility of a Tablet-Based Decision-Support and Integrated Record-Keeping (DESIRE) Tool in the Nurse Management of Hypertension in Rural Western Kenya. *Int J Med Inf*. 2015;84(3):207-219. doi:10.1016/j.ijmedinf.2014.12.005
19. HA YP, TESFALUL MA, LITTMAN-QUINN R, et al. Evaluation of a Mobile Health Approach to Tuberculosis Contact Tracing in Botswana. *J Health Commun*. 2016;21(10):1115-1121. doi:10.1080/10810730.2016.1222035
20. Theiss-Nyland K, Ejersa W, Karema C, et al. Operational challenges to continuous LLIN distribution: a qualitative rapid assessment in four countries. *Malar J*. 2016;15:131. doi:10.1186/s12936-016-1184-y
21. Campbell JI, Aturinda I, Mwesigwa E, et al. The Technology Acceptance Model for

Resource-Limited Settings (TAM-RLS): A Novel Framework for Mobile Health Interventions Targeted to Low-Literacy End-Users in Resource-Limited Settings. *AIDS Behav*. 2017;21(11):3129-3140. doi:10.1007/s10461-017-1765-y
22. Clouse K, Phillips TK, Camlin C, et al. CareConekta: study protocol for a randomized controlled trial of a mobile health intervention to improve engagement in postpartum HIV care in South Africa. *Trials*. 2020;21(1):258. doi:10.1186/s13063-020-4190-x
23. Managerial Tools for IS4H Digital Transformation - PAHO/WHO | Pan American Health Organization. Accessed March 31, 2023. https://www.paho.org/en/managerial-tools-is4h-digital-transformation
24. FACILITY HIT ECOSYSTEM CAPABILITY MATURITY MODEL TOOLKIT. Accessed February 8, 2023. https://www.regenstrief.org/wp-content/uploads/2020/07/facilityhitecosystem-capabilitymaturitymodelandtoolkit-072020.pdf
25. Readiness Assessment Maturity Model. Published online 2021.
26. Khoja S, Scott RE, Casebeer AL, Mohsin M, Ishaq AFM, Gilani S. e-Health readiness assessment tools for healthcare institutions in developing countries. *Telemed J E-Health Off J Am Telemed Assoc*. 2007;13(4):425-431. doi:10.1089/tmj.2006.0064
27. Tools for Data Demand and Use in the Health Sector — MEASURE Evaluation. Accessed April 28, 2023. https://www.measureevaluation.org/resources/publications/ms-11-46.html
28. Data-Driven Innovation: Big Data for Growth and Well-Being. Published online 2015. https://doi:https://doi.org/10.1787/9789264229358-en
29. Trebble TM, Hansi N, Hydes T, Smith MA, Baker M. Process mapping the patient journey: an introduction. *BMJ*. 2010;341:c4078. doi:10.1136/bmj.c4078
30. Consortium DH and RP, Davis SLM. Towards digital justice: participatory action research in global digital health. *BMJ Glob Health*. 2022;7(5):e009351. doi:10.1136/bmjgh-2022-009351
31. Pratt B, Sheehan M, Barsdorf N, Hyder AA. Exploring the ethics of global health research priority-setting. *BMC Med Ethics*. 2018;19(1):94. doi:10.1186/s12910-018-0333-y
32. Pratt B, de Vries J. Community engagement in global health research that advances health equity. *Bioethics*. 2018;32(7):454-463. doi:10.1111/bioe.12465
33. Pratt B, Cheah PY, Marsh V. Solidarity and Community Engagement in Global Health Research. *Am J Bioeth AJOB*. 2020;20(5):43-56. doi:10.1080/15265161.2020.1745930

Supplementary Files

Figures

Key Features and Questions.