Journal of Health Informatics in Africa

Official Journal of the Pan African Health Informatics Association (HELINA)
published by Koegni-eHealth Innovation for Development
HELINA is the Africa Region of the International Medical Informatics Association (IMIA)

Volume 7 (2020) Issue 1

Eds: Nicky Mostert, Ghislain Kouematchoua, Ulrich Kemloh

ISSN: 2197-6902
DOI: 10.12856/JHIA-2020-v7-i1

JHIA : www.jhia-online.org
HELINA : www.helina-online.org
IMIA : www.imia-medinfo.org

Published in the Journal of Health Informatics in Africa
Volume 7 (2020) Issue 1

ISSN: 2197-6902
ISSN/NLM abbreviation: J Health Inform Afr
DOI: http://dx.doi.org/10.12856/JHIA-2020-v7-i1

Publisher
Koegni eHealth, Innovation for Development e.V. Germany
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D-22372 Hamburg, Germany
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Editorial to JHIA Vol. 7 (2020) Issue 1

Nicky Mostert[a]

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The Journal of Health Informatics in Africa is the official journal of the Pan African Health Informatics Association (HELINA) and publishes the proceedings of the HELINA conferences, as well as open-call issues. This issue is an open-call issue comprising of four papers submitted directly to the journal. These papers have been double blind peer-reviewed before being accepted for publication. Although papers written in French are also published by the journal, all four papers in this issue was written in English.

The paper by Egwar, Wamema, Kiwanuka and Bagyendera investigates the success of eHealth standards adoption and proposes a conceptual model for assessing the potential success of eHealth standards adoption.

Authors Ashaba and Nabukenya employed a cross-sectional survey to investigate the practises and challenges associated with the evaluation of eHealth interventions in Uganda. They highlight the need for an evaluation framework to guide the evaluation of eHealth interventions.

Jheelan-Ramchandur, Jodheea-Jutton, and Nagowah reports on the development of an e-tool to facilitate the prescribing of medications in Mauritius. A prototype of a mobile drug formulary application was developed for healthcare professionals in Mauritius in an effort to reduce prescribing errors and faults.

Munene, Egwar, and Nabukenya identified the need for and suggests a structure for a digital health curriculum for the African region.

This year has proved to be trying on all as we live through the COVID-19 pandemic. I would thus like to extend a very special thank you to the editorial team, authors, and peer-reviewers that made this issue possible. The peer-reviewers all took time out of their abnormally busy schedules to assist with the review process, for which we are very appreciative and thankful.

Nicky Mostert
10.10.2020

Journal of Health Informatics in Africa

Introducing a Mobile Drug Formulary for Healthcare Professionals in Mauritius

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Background and Purpose: Prescribing errors and faults are common in medical practice and are more prevalent among young doctors. These are mainly due to erroneous medical decisions that can unfortunately cause much harm to the patients. This study aimed at exploring avenues of promoting medication safety by providing comprehensive details about the branded medications available in the Mauritius market through the development of a mobile Drug Formulary application for Mauritius.
Methods: Drug information were sought from pharmacies and wholesalers. The medications were categorized anatomically and relevant information about each medication was retrieved from established databases such as the British National Formulary and Vidal. A mobile framework was designed which allowed an administrator to upload a list of drugs on a cloud environment and the mobile devices to connect to this environment on start-up to download the updates, if any, to the local device.
Results: A database has been created with the existing medications provided by the participating wholesalers in Mauritius. An Android and iOS compatible mobile application was developed that linked to the database on the cloud and enabled loading of all information on demand. A user-friendly prototype with access to comprehensive information about drugs currently available on the Mauritian market was hence implemented.
Conclusions: This is the first initiative to develop an e-tool to facilitate the prescribing of medications in Mauritius. Further work is underway to improve the database as well as setting up of a reliable strategy for updating the database.

Keywords: Drug Formularies, E-health, medication safety, Mauritius, mobile application

1 Introduction

Drug safety is an important pillar in delivering quality healthcare and ensures that patients are prescribed and dispensed medications in the safest possible way. Stringent strategies such as Food and Administration regulators, pharmacovigilance and drug monitoring systems regulate all stages in drug development process including conception of a drug, marketing and monitoring of the adverse drug reactions. Despite rigid control, evidence shows that patients are increasingly facing the outcomes of poor prescribing practices. Mauritius, a developing nation is not spared from this precarious tendency.

Mauritius is a middle income, sub-Saharan country, situated on the East coast of Africa. With a population of 1.2 million and a yearly influx of around one million tourists, it has experienced major development in the economic and tourism sectors. The health system is an essentially free system where more than 80% of the population use the public sector [1]. The welfare state uses the principles of free

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health for all through the access of free medical services from primary care to secondary [2]. Health is delivered through a decentralized 5-zone system where each zone is guided by its respective Health Advisory Board, which acts under the umbrella of the Ministry of Health and Quality of Life (MoHQL), the main governing body for the health system in the country. The MoHQL is responsible for all health-related policies, regulations, and coordination both nationally and internationally [3].

An important aim of the MoHQL is to improve the quality of life and well-being of the population through the prevention of communicable and non-communicable diseases, the promotion of healthy lifestyles and an environment conducive to health. Mauritius has undertaken major leaps in the control of communicable diseases [4] and is at present tackling the rising trend of non-communicable diseases [5]. Capacity building has been the major priority for the MoHQL leading to the training of doctors and pharmacists locally. This has contributed to a boost in the number of doctors and pharmacists practicing in Mauritius, especially in the private sector. There has been an emphasis to further develop the private health system in Mauritius through the promotion of health insurance to meet the needs of the growing population. Private health care is delivered essentially through the 17 private clinics, which provide a high level of diverse medical services and up to date technologies. They are the biggest prescribers of branded medications in the country.

The MoHQL encompasses the pharmacy board and the pharmacovigilance committee, which ensure the proper drug registration and monitoring of drugs coming on the market. There is only one locally situated drug company, while most of the drugs used in Mauritius are imported from several countries across the globe. In 2019, Mauritius spent around 136 million USD on imports of drugs and the private sector accounted for 75% of the imports while the MoHQL accounted for essentially generic products [6]. Branded products came from India, South Africa, France, Germany, and the United Kingdom, where India had been the biggest supplier. There were 33 registered wholesale distributers in the country.

It is established that the private pharmaceutical company is an integral part of the health system. However, there is lack of guidance and information on the branded products that are currently available on the Mauritius market. With imports from different countries, one formulary is unlikely to meet the needs of the medical practitioner. There has been a demand for a tool that combines all the medications that are available in clinics and pharmacies in Mauritius. Hence, an innovative tool that offers a list of currently available branded medications through the use of smartphone applications has been proposed with a view to support safe prescribing in the country.

In this paper, we review the currently available mobile drug formulary applications and report on the development of a digital formulary in the form of a mobile application for the Mauritian market, where safe prescribing has become a national priority requiring immediate attention. We document the different stages in the development of the application and discuss the implications of such a tool in the Mauritian healthcare industry.

1.1 Literature review

A drug formulary contains a list of medicines that are usually approved for prescription throughout the country [7]. It typically includes data on the indication, caution, contra-indication, dosage, side effects and composition of the drugs. There are several national formularies available, for example, the British National Formulary, the Australian Pharmaceutical Formulary, the National Formulary of India and the Jordan National Formulary amongst others. The World Health Organization has also published a WHO Model Formulary which is deemed helpful for countries who wish to develop their own National Drug Formulary [8].

A unique situation prevails in Mauritius whereby the formularies commonly used by doctors and pharmacists are the Vidal, the British National Formulary and the Martindale. In December 2016, the Ministry of Health and Quality of Life implemented General Guidelines for antibiotics prescription with the aim of promoting judicious use of antibiotics and to minimize the spread of resistant organisms [9]. The MoHQL has also recently developed a list of essential drugs but it contained only the names of the generic drugs available on the Mauritian market. Therefore, the need of a comprehensive drug formulary for the country is of utmost importance [10]. Table 1 highlights the primary aim and features of some common mobile drug formulary applications.

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Table 1: Features of some common drug applications

App Name	Aim	Features
Drug Formulary [11]	To provide evidence-based knowledge and tools to help prevent cancer and deliver high-quality care	Access to evidence-informed regimen information for healthcare professionals and patients. Information about public funding and reimbursement programs and forms for prescribing take-home chemotherapy.
Formulary Search [12]	Aims at being the single source of reliable and current drug coverage and restriction information for prescribing doctors	Updated nightly, ensuring that doctors have the data points needed to guide prescribing decisions for patients. It includes over 6,500 health plans, drug access across location and channel, search coverage information by various forms of a drug and alternative drug coverage information.
Mosby's Drug Reference for Health Profession [14]	Advertised as a must-have item for every current or aspiring health professional in the field today	Concise, reliable information that is easy to navigate and simple to follow. Key details are presented in short monographs for 1,000 generic drugs (including 4,500 trade-name drugs) that are listed alphabetically and that include drug name, pronunciation, trade name(s), category and schedule, classification, mechanism of action, pharmacokinetics, availability, indications and dosages, contraindications, interactions (drug, herbal, and food), diagnostic test effects, side effects, serious reactions, and precautions and considerations. It also features information about chemotherapy, ophthalmic, and other pertinent drugs.
The Medscape mobile application [15]	Features a drug reference tool with the current prescribing and safety information	A drug interaction checker, medical calculators, procedure reference and formulary information are also found in the app. Moreover, healthcare professionals can interact with a community of physicians over the world to ask questions, share cases and gain from their knowledge and experiences

Haffey et al. [16] conducted a search on the six main smartphone application stores and provided a list of applications designed for healthcare professionals. These applications provided drug reference and prescribing materials. They reported that some applications included drug calculation capabilities, drug dose or infusion calculator functions, drug interactions, support for e-prescribing apps and drug formularies. Some applications included a drug reference resource for logging clinical events and medications while others allowed the pharmacists to monitor their patients-controlled drug usage

Based on the overview of drug formulary mobile applications, a critical analysis has been performed highlighting the main features and weaknesses of these mobile applications. It was observed that many drug formulary mobile applications offer a comprehensive drug database with detailed drug information such as name, dosage, pregnancy, drug reactions amongst others. Many of the applications are quite established and are regularly updated to cater for new or discontinued drugs. Offline support is also an important functionality where the application can be used without any internet connection. Some mobile applications include other functionalities such as price comparator, reminders and disease dictionary among others.

However, it was also noticed that many mobile applications were specific to countries. Some examples include the specially designed application for the Philippines, EMDEX 2017 for Nigeria and Medical Guide App Pakistan with an authentic list of brands of all pharmaceutical companies of Pakistan. Many medical schools also had mobile applications for their students. Examples include UBC Med Formulary for University of British Columbia (UBC) medical school and Personal Formulary for University of Liverpool

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medical students. Therefore, since the brand names are specific to one country, the existing mobile drug formulary applications do not reflect the list of brands available on the Mauritian market.

2 Aims

The uses of a drug formulary have evolved with time and technology, from a simple list of medications to be used by a specific institution to a specialized mobile application providing accessible information about complex and new medications within a simple click. The fast pace of development in this sector has pushed for applications and formularies with refined features to adapt to the growing needs of a varied population. The aim of this study is to provide a tool that assists in prescribing and dispensing as well as reduce medication errors in Mauritius. At present, there are limited guides to prescribing especially in private practices. The prototype has been tailored to the Mauritian market and therefore contains a database of medications available locally. The primary aims of the study are to:

- Develop the prototype of a formulary that suits the Mauritian context,
- Assess the opinions of the different stakeholders during and after the development of the prototype, and,
- Reflect on the feasibility of the implementation of such a system for Mauritius.

We anticipate that the provision of such a tool will definitely enhance the safety of medication prescribing.

3 Materials and methods

This section of the paper reports on the methods used to design and develop the drug formulary application. The main steps of our methodology include the building of the mobile application and validating the mobile application through stakeholder workshops.

3.1 Developing the application

The application was developed based on a classical client-server architecture comprising of a client mobile application and a server with data storage capabilities, as illustrated in Figure 1. The client mobile application was also connected to an offline database for local data storage.

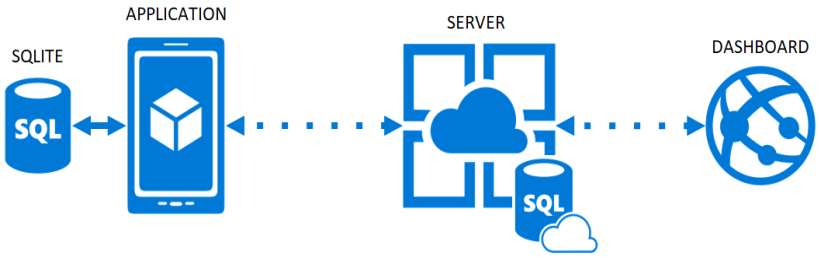

Figure 1: Overall Architecture

The application process consisted of the client initially connecting to the server, a cloud service, to check for new drug formulary records. The cloud service in turn connects to the database to fetch any newly added records and returns the data to the client. Finally, the client saves the data locally (on the phone itself) so that it may be accessed even in the absence of an internet connection.

The mobile application was developed using Xamarin Forms – a development platform that allows the creation of a single application catering for all major systems (Android, iOS and Windows). It was also supported by SQLite for local data storage. The cloud service was developed in ASP.NET Core and hosted on Microsoft Azure. It was designed as a mobile service, hence allowing the mobile application to connect to it and fetch data with ease. The cloud service can be accessed and managed for administrative purposes from a custom web application, also developed in ASP.NET Core. The data storage was enabled through

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Microsoft Azure SQL that allows persistent saving of data and also provides the necessary infrastructure for external entities (such as the mobile application or the cloud service) to access the data. The dashboard is a password protected admin website that will be used by the administrator(s) to update the list of drugs on the system.

3.2 Acceptability of the application

Three focus groups were organized to discuss the importance and acceptability of the project as well as provide feedback on ways to improve the application. Stakeholders invited included policymakers and representatives from the Ministry of Health and Quality of Life, members from the different committees such as the pharmacy board, the pharmacovigilance committee, the medical council and the pharmacy council. Doctors and pharmacists working both in the private and public sector as well as academics and scientists were also invited.

A presentation was made to introduce the application and the main features of the application. Post presentation, a discussion was initiated inviting stakeholders to comment on the importance of the application and suggestions for features. Notes were taken by the different investigators and were reviewed and discussed by the team members.

A second meeting was organized with the members of the Ministry of Health and Quality of Life to discuss the project, where the emphasis was essentially on the feasibility and importance of such a project for the country and for the MoHQL.

The third and final focus group was essentially gathered to review the final version of the application and discuss the implementation of such a system in Mauritius and the potential barriers and solutions. The team members then analyzed all the data qualitatively using a thematic approach.

4 Results

The Drug Formulary Application consisting of two main components: the mobile application and the drug formulary website, is presented in this section, which also outlines the main feedback obtained during the stakeholders' meetings.

4.1 The Mobile Application

The splash screen (Figure 3) appears at the start of the application. In the background, an attempt is made to connect to the Azure website to check for any updates. If there are updated records, these are downloaded automatically on the mobile phone. If there is no internet connection, the previously downloaded data is made available to the user.

The main screen of the application (Figure 4) consists of the logo and three buttons that shall direct the user to the following sections:

- Browse All – Here the user can browse all the drugs sorted in alphabetical order.
- Categories – The section groups the drugs as per the different categories. There are 15 categories altogether.
- Search – The responsive search of the mobile application.

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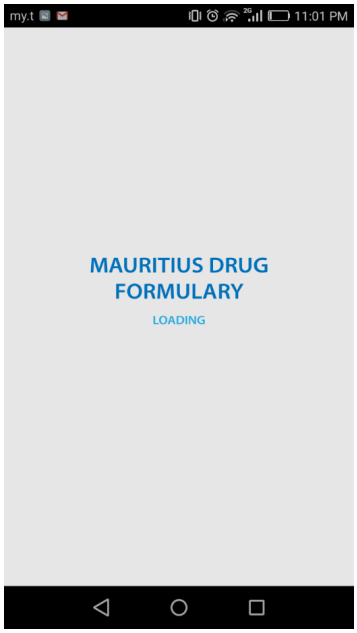

Figure 3: Splash Screen

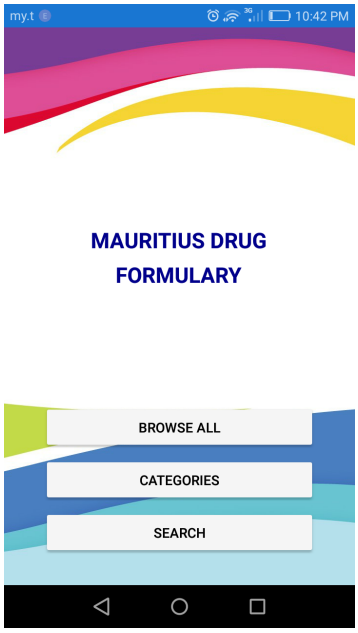

Figure 4: Main Screen

The mobile application has been implemented in such a way that it provides a list of drugs tailored for the Mauritian market. The following details, as shown in Figures 5 and 6, are retrieved for each drug: *indications, class, category, preparations, dosage, cautions, contra-indications, side effects, pregnancy warnings, breastfeeding warnings* and *interactions*. The intuitive user interface easily alerts the user if a drug is classified as high risk.

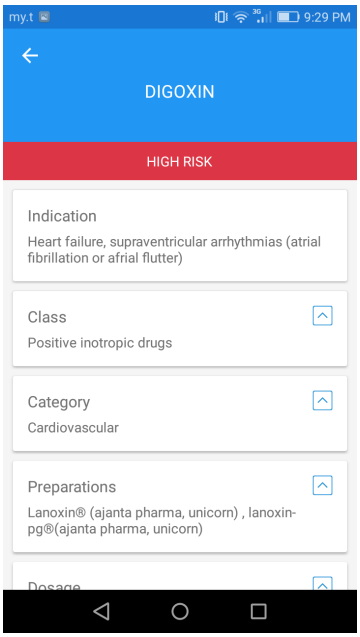

Figure 5: Drug Details

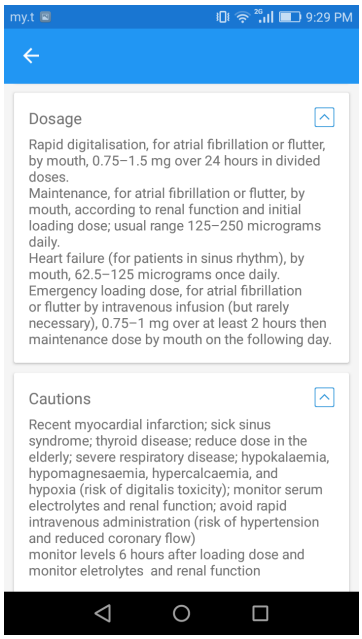

Figure 6: Drug Details

The list of drugs has been classified according to the human anatomical system and therefore the application contains 15 categories (Figure 7), namely: *anaesthesia; cardiovascular; central nervous system; ear, nose and oropharynx; endocrine; eye; gastro-intestinal system; immunological products and vaccines; immunosuppressants and cancer; infections; musculoskeletal and joint diseases; nutrition and*

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blood; obstetrics, gynecology and genito-urinary; respiratory and *skin*. The mobile application also provides a responsive search, shown in Figure 8, that can locate drugs containing a particular keyword. As the user types in the search text, the application refines its list of results. An advanced search feature has also been implemented for more precise queries that could be filtered by each of the different fields. For convenience, a list of recently opened items is also displayed to the user whenever the search page is loaded.

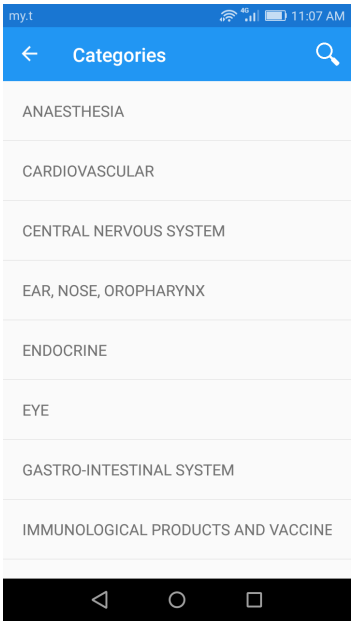

Figure 7: Categories

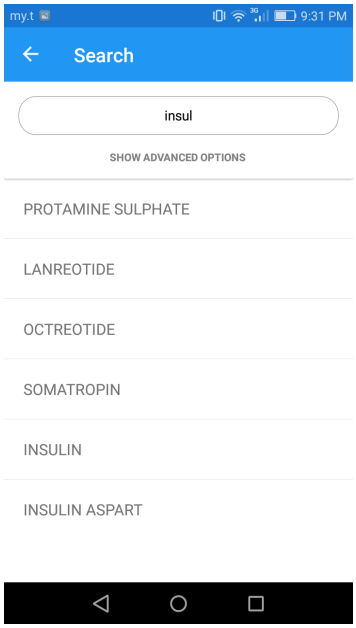

Figure 8: Responsive Search

4.2 The Drug Formulary Website

The Drug Formulary website consists of two main sections:

- A section providing information on the mobile application, its features and other general information accessible to the public.
- A password-protected administration section that is used by the administrator(s) to update the list of drugs on the system.

4.3 Stakeholder feedback

Several themes evolved during the group discussions, namely the importance of such a database for Mauritius and its application in the country, barriers to the implementation of such a system and the need for multi-stakeholder collaboration.

- **Promoting Medication Safety**

The stakeholders present were very enthusiastic about the project since such an application was missing for the Mauritian market. There has been a growing demand for a database or formulary that enlists all medications and brands available in Mauritius. They immediately realized the need and importance of the application as an essential safety tool and more specifically, how the application would be beneficial in the day-to-day execution of their duties.

Some stakeholders described it as 'an easily accessible tool for quick information retrieval' and if geared to the local context, might be highly beneficial as it can promote safer prescribing and dispensing among healthcare professionals. The areas where the tool can be important included highlighting the high-risk

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groups of medications and precautionary advice. They also stated that the application could be a vital tool for new doctors starting their private practice.

- **Improving the Application**

A number of relevant feedback was obtained which the project team did not initially think about. The most recurring and important features were given a higher priority and were implemented accordingly. The workshops proved to be very beneficial as a lot of interesting feedback was received, some of which have been listed below:

- Inclusion of a Drug Interaction section to highlight possible interactions between drugs.
- Incorporation of high-risk medications to visually notify the healthcare professionals of drugs that can pose significant danger to the patient's safety.
- Hepatic and renal impairment, i.e. to inform the health care professionals about the possible effects of drugs in the case of dysfunctions of the liver and the kidney.
- Inclusion of memory of drugs recently visited
- Inclusion of drugs by brand names and wholesalers on the Mauritian market
- Development of an iOS-compatible version
- Regular updates (ideally 6 months) that can be catered through a membership fee
- Collaboration with the Ministry of Health and Quality of Life

- **Barriers to Implementation**

Although the application has been welcomed by several stakeholders, some barriers to the use of the application have been identified including the cost of the application. There are a number of free resources that are currently available and are being used by most healthcare professionals. Therefore, the usage of mobile drug formulary application will depend on the benefits conferred as well as accessibility and the cost of the application.

Additionally, fierce competition with Android applications might make it look less attractive. Another important feedback received has been to regularly update the application which might eventually have an implication on human resources and costs. All stakeholders unanimously agreed that the leading health agency that regulates drug licensing and sales in Mauritius need to collaborate to ensure regular update of such an application.

Local and international wholesalers can also collaborate to update researchers/administration about medication alerts and changes.

5 Discussion

The formulary has been shown to be an established tool worldwide to assist in the prescribing and dispensing practice. The absence of a thorough and up-to-date list of medications in the Mauritius market necessitates the introduction of an affordable, user-friendly and reliable tool that caters for patients and healthcare professionals' unmet educational needs. This project is an attempt to develop such a tool that can foster a healthy prescribing and dispensing practice. The first phase of the study enabled the shortlisting of specific features required for the application, development of a drug database and the design of a prototype for the mobile application.

The prototype was demonstrated in workshops facilitating the validation of the features and the tool. This initiative has been welcomed by members of the medical and pharmaceutical professions.

The choice of medications included in this formulary relies on the participation of the interested stakeholders. However, with the evolution of drug formularies worldwide, new criteria have been stipulated to facilitate the inclusion of medications that are cost-effective in specific formularies. For example, in the US, the approval of specialty medications by the FDA leads to the coverage of the medication by Medicare [17]. The authors reviewed the monograph prepared by a clinical pharmacist which was reviewed by a physician to decide on its suitability for the formulary. The Drug Formulary is currently at its conception phase. The prototype provides a model to be used during the consolidation phase of the formulary. The conventional choice of medications to go on a formulary depends on the needs of the health system. The safest and cost-effective medications are given priority as the role of a formulary is

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to promote cost-effective prescription of medications. However, the absence of a comprehensive list of essential medications in Mauritius calls for a list of medications that can guide new practitioners on prescribing, which can eventually lead to reduced prescribing errors. The Drug Formulary serves the purpose of bringing together the list of branded medications that will cater for the needs of practitioners joining the health system as well as experienced practitioners wanting to try something new safely.

- **Implications of the project**

Several countries are in a similar situation as Mauritius, where there is a need for a comprehensive list and guidance on branded medications. However, resource-limited countries struggle to put such a system in place due to economic and political barriers. Although a very interesting concept, maintaining the quality of the output can be challenging as it demands human and financial resources. Similar Applications are already available such as the Drugs.com [18] which is a database of more than 20 000 drugs and provide general drug related advice. Although it can be used across the world, the information provided can be less useful in different countries due the complexity of the drug import system. While an affordable and cost-effective tool is highly desirable, the systems in several countries might not support the development of such a tool due to poor health system [19]. With the advocacy on E-health, global internet coverage and easy access to smartphones, several countries might consider the formulation of such a digital, safety-enhancing tool. However, this project is in its infancy stage and there are needs for further trials and evidence to facilitate its implementation.

- **Limitations of the Design and Methodology**

The mobile application has been compiled as an Android APK and tested on several Android mobile phones. Although a cross-platform technology was used, the application could not be tested on iOS and Windows devices due to lack of appropriate devices.

The Android mobile application was found to be responsive once the data has been downloaded on the device. However, the initial fetching of drugs takes some time depending on the internet connection. In terms of the functionalities, the stakeholders suggested some cosmetic changes in the third workshop such as personalizing the colors, zooming on the different parts of the application and change the font and its size.

Stakeholders further requested additional options such as personalizing the high risk of medications to the local market based on current practices and malpractices as well as integrating certain features such as a pill check. The next phase of the project aims at reviewing the practicality as well as the importance of additional features in the tool, hence will provide an opportunity to consider the feedback provided.

Although the stakeholders have welcomed the application as a tool to improve prescribing safety, its efficacy needs to be assessed and addressed in the next phase. The practicalities of using such a tool in real life will enable further adaptation of the application.

- **Challenges and Future Directions**

A number of challenges were encountered in the development of a Mauritian Mobile Drug Formulary and are listed below.

  - List of Medications from the Ministry of Health and Quality of Life were not readily available.

A complete list of medications registered on the local market is found at the Ministry of Health and Quality of Life. Negotiations are underway to gain access to the list for consolidating the database and regular updating of the currently available medication list. However, as we had expected, we have to seek appropriate approval from higher authorities for the use of the information which are generally not available to the general public.

  - Reluctance of pharmacies and wholesalers to share the list of drugs

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Most of the Mauritian pharmacies and local and international wholesalers were contacted requesting information pertaining to their individual list of medications in Mauritius. However, only two wholesalers shared their list to be used in the mobile application.

- Reluctance of Wholesalers to share their price list

Wholesalers were not willing to give access to their price drug list. Consequently, it was difficult to include the price of the medications in the application. We were of the opinion that, may be, the wholesalers might fear the fact that their competitors would know the price of similar drugs and hence they might lose a competitive advantage over the others.

- Human power for the development and maintenance of a mobile drug formulary

Human resource was limited due to restricted funds. Ideally, a full-time research assistant had to be recruited for the collection, filtering and verification of the data. The collection of data was also time consuming since the data was manually verified and inputted on the system.

- Dynamic nature requiring regular updates

Such a drug formulary in Mauritius will need regular updating once it is officially launched. Therefore, a mechanism must be thought carefully before embarking on the marketing of the mobile application.

- Efficacy of such a tool in promoting medication safety

Although the main aim of this tool has been to promote safety of medication prescribing, we currently lack objective and quantitative data to show the efficacy of the formulary as a safety enhancing tool. While all the stakeholders agree that it is an essential tool in improving safe prescribing, there is nevertheless the need to do a further investigation to demonstrate the efficiency of the mobile Drug Formulary application in the prescribing process in Mauritius.

6 Conclusion

The medical errors related to prescribing and dispensing of medications can lead to life threatening incidents as recently experienced in Mauritius. This calls for urgent strategies to promote safer prescribing and drug administration practices. A user friendly and affordable tool such as the Mobile Drug Formulary Application in Mauritius can definitely help to improve the current prescribing standards. However, before envisaging a potential marketing of the product, the refinement and improvement of the prototype will be of utmost necessity. Trialing of the application among prescribers in Mauritius will also be important so as to test its efficacy. Furthermore, there will be a need to update the database and peer review the medications on a regular basis. Continuous collaboration with important stakeholders will be essential for the consolidation and implementation of the tool.

Acknowledgements

The authors are thankful to the two research assistants, Mr. Vidush Hemnayan Namah and Mr. Shanoo Suroowan, who have helped in the development of the mobile application and the drug database.

Funding

This project was funded by the Mauritius Research Council under the Small Scale Research and Innovation Grant Scheme. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Mauritius Research Council and the Ministry of Health and Quality of Life of Mauritius.

 J Health Inform Afr. 2020;7(1):1-11. DOI: 10.12856/ JHIA-2020-v7-i1-217

Statement on Conflict of interest

The authors declare that there is no conflict of interest.

Author Contributions

All authors have contributed equally to the work and have read and approved the final manuscript.

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 J Health Inform Afr. 2020;7(1):1-11. DOI: 10.12856/ JHIA-2020-v7-i1-217

Journal of Health Informatics in Africa

Assessing Evaluation of eHealth Interventions in Uganda: Practices, Challenges and Insights

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Background and Purpose: Electronic health (eHealth) is the use of information and communication technology (ICT) to support healthcare. It is becoming more popular in healthcare management with expectations of improved effectiveness, access, quality, and efficiency of the healthcare systems. The increased investment and implementation of eHealth across the world calls for its evaluation to evidence its value. This study thus aimed at investigating the practices, challenges, and suggestions for optimising evaluation of eHealth interventions in Uganda.
Methods: A cross-sectional survey was used to conduct the investigation among key eHealth implementing institutions in Uganda. Primary data provided by 22 participants from 18 institutions was used to establish an understanding of the institutions' perspectives with respect to eHealth evaluation practices and challenges faced, as well as to derive insights from these perspectives in relation to the World Health Organization (WHO) understanding of digital health evaluation.
Results: The study revealed that various eHealth interventions are implemented in Uganda; however, very little of their evaluation is undertaken, as it is not a key activity with most of the eHealth implementers. Focus is put on monitoring the eHealth initiatives' functionality and adoption rather than their outcome and impact. Limited skills/capacity and unavailability of national guidelines on eHealth evaluation were reported as key limitations.
Conclusions: Accordingly, the study recommends the need for an evaluation framework to elucidate and guide on the notion of evaluation, its characteristics, and measurement indicators regards the outcome and impact of eHealth interventions in healthcare and service delivery for Uganda's health system.

Keywords: eHealth, evaluation, monitoring, results-based management

1 Introduction

Across the world, healthcare systems are facing pressures to guarantee simultaneously accessible, quality, and affordable care. Healthcare administrators and policymakers are expected to implement interventions that increase the quality and efficiency of services, care, and support high performance of health systems [1] [2] [3]. eHealth, the use of information and communication technologies (ICT) for health [4] is becoming more popular in healthcare management and has proved to improve the effectiveness, access, quality and efficiency of the healthcare systems [5] [6] [7] [8]. The definition of eHealth by [4] accommodates a variety of medicine and public health applications including patient and public health data management (electronic health records), provision of remote health care services (telemedicine/teleHealth), health information and services through mobile telephone technology (mHealth), health knowledge management and distant learning for health workers (eLearning), connection of medical devices (internet of things), and other areas like improved planning, organization, and management of health services, and more recently the management of large public health data [9]. eHealth applications allow communication between healthcare providers and their clients, and sharing of information and knowledge among healthcare providers [10]. The Internet has also been used for communication and it has contributed to better disease management [11] [12].

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

Learning from the developed world, sub-Saharan African and other developing countries are implementing ICT solutions as a means to improve accessibility to quality and equitable healthcare for poor and vulnerable communities [13]. In sub-Saharan Africa, the early use of ICTs in health was evidenced in the use of various mobile health solutions in multiple countries [14] and telemedicine in West Africa [15]. Currently, there is an increase in eHealth implementation on the continent and leading implementations including mHealth, eLearning, and telehealth. Social media, electronic health records and implementation of digital medical devices are also gaining popularity on the continent [16] [17]. There is much interest internationally in exploiting the potential of ICTs to improve healthcare [16] [18] [19] [20] because the proper use of ICTs in healthcare enable more efficiency in information processing and impact on access and quality of care [21] [22] [23]. WHO [16] further notes that the application of eHealth is necessary if universal health coverage is to be realised.

The increasing investment in eHealth has called for its evaluation to generate evidence that there are benefits realised from eHealth applications. Such evidence helps to establish the return on investment and guides future eHealth investment and adoption decisions. Evaluation for eHealth interventions helps to generate data used to assess whether observed changes in behaviour; processes or health outcomes can be attributed to the interventions [24] [25]. The concept of evaluation can be defined as a systematic and objective assessment of an intervention that aims to determine the fulfilment of objectives, efficiency, effectiveness, impact, and sustainability [26]. WHO [25] further defines evaluation, as measures taken and analysis performed in order to assess the interaction of users or a health system with the digital health intervention strategy, or changes attributable to the digital health intervention. Related to evaluation is monitoring, in which monitoring and evaluation are sometimes used interchangeably, yet the two concepts are different in the context of measuring performance and impact of eHealth interventions. [25] emphasizes that monitoring is the routine collection, review, and analysis of data intended to measure implementation progress for an eHealth initiative, and results into adjustments in intervention activities necessary to maintain or improve the quality and consistency of the eHealth deployment. In contrast, evaluation measures changes in health outcome and impact that are attributed to the eHealth initiative.

Notwithstanding the challenges, eHealth evaluation efforts are worth undertaking [27]. Implementers and countries that have evaluated their eHealth implementations have benefited from the knowledge about results of the implementations in the respective programmes [24] and this knowledge base helps to inform decisions on policies, practices, and research [28]. In Europe, the topic of impact assessment as well as evaluations for eHealth had gained considerable momentum by 2011 to an extent that half of the countries had designated a specific body/institution that was responsible for eHealth evaluation activities. Various Canadian eHealth evaluation studies evidenced positive benefits from the implementation of electronic medical records and drug information systems [29] [30] [31], and such helped to answer questions concerning whether there was sufficient value for money on Canadian electronic health records investments which were earlier raised in 2009-2010 performance audit reports by the Auditor General of Canada and six provincial auditors offices [32]. In 2010 Canada's International Development Research Centre (IDRC) conducted an evaluation of its 25 eHealth projects funded between years of 2005 and 2010 in 28 countries in Africa, Asia and Latin America and the Caribbean (LAC). The projects (50% from Africa, 28% from LAC, and 16% from Asia) focused on contributing evidence and knowledge about how to use technology to help solve health challenges through either the use of eHealth tools to tackle one or more specific challenges, or general health systems strengthening. The evaluation results showed contributions of the projects in the regions and informed IDRC's future programming in eHealth research [33]. Evaluation done for the United Kingdom's implementation and adoption of the nationwide electronic health records system indicated limited visible benefits for clinicians and patients, and it guided the eventual closedown of the initiative [34] [35]. An assessment that sought to find out the successes and challenges of eHealth in Africa and developing countries [36] indicated that most of the initiatives lacked documentation and proper evaluation hence their overall success was uncertain, but led to recommendations that would guide future implementations to do well. All the above cases communicate how eHealth evaluation has been given attention in some countries and how the evaluation results have been useful to inform decisions.

Evaluation of eHealth implementations is a challenging undertaking [24] [37] [38] and there are a few published evaluations on eHealth implementations [7] [39] [40] [41] [42] [43] especially in the developing countries [38] including Uganda [44]. The difficulty is because such evaluation does not focus on technology only but often needs to consider how the technology components interact with other processes

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in the eHealth implementation [45], which in turn broadens the scope of the evaluation [46] [47]. Secondly, the evaluation takes place in a complex healthcare setting that involves multiple stakeholder categories (such as patients, clinicians, administrators, IT specialists, funders) on top of legislation, social, political and economic environments [48]. This poses challenges to the evaluation since different stakeholders present different expectations and perspectives of a successful eHealth implementation, which may lead to conflicting evaluation criteria, and require multiple study designs and evaluation methods [37] [49] [50]. eHealth evaluations are also resource-intensive and are always hampered by insufficiency of resources like time, funding, human resources, and subject participants [37]. Due to various eHealth evaluation complexities, various literature recommend the use of frameworks or some other type of organizing schemes to help in guiding the evaluation process but also making sense of eHealth systems and evaluation findings [24], [25].

Uganda, like most developing countries, has employed eHealth applications to improve healthcare delivery and public health [13]. Its National eHealth Policy and Strategy [51] were also developed to guide the development and implementation of eHealth in the country. The National eHealth Strategy (2017) further stipulates the need to evaluate digital health interventions and keep track of their results in terms of outcomes and impact; however, most eHealth processes are not systematically documented and lack ongoing monitoring or measurement mechanisms [44]. To this end, this study sought to investigate and document the extent to which Uganda's eHealth interventions are evaluated, the practices and challenges faced, as well as propose suggestions for improvement in evaluation of eHealth interventions in Uganda.

2 Materials and methods

The cross-sectional survey was used to collect data because it was found to be more suitable in describing the current situation on evaluation of eHealth interventions in Uganda. Cross-sectional survey is a method that is used to collect data at a particular point in time [52]. Particularly, we used the survey questionnaires to investigate the practices and challenges in evaluation of eHealth interventions. The authors through consensus developed the questionnaire with both closed and open-ended questions on the following topics; organization and respondent information, the use of eHealth in organisation activities; organisation practices, motivations and challenges in eHealth evaluation; performance indicators for eHealth evaluation; existing tools and resources for supporting eHealth evaluation, and their suggestions on ways to improve eHealth evaluation.

Primary data was collected from twenty-two (22) key informants from eighteen (18) key eHealth implementing institutions in Uganda through face-to-face semi-structured interviews with each informant following the developed questionnaire. Face-to-face sessions allowed an opportunity for probing more information and seeking clarification where necessary. Informants from the same institution belonged to different departments with differing practices regarding eHealth implementation and evaluation. Among the institutions included the Ministry of Health and its international development partners, national implementing partners, research/academic institutions, and health facilities; with each institution having the possibility of belonging to more than one category.

The institutions were selected using a combination of purposive and convenience sampling. Initially, the Ministry of Health (MoH) Division of Health Information (DHI), which is the custodian of eHealth and health information management in Uganda, was contacted to recommend the key eHealth implementing institutions to participate in the study. Out of the twenty-five (25) recommended institutions, three (3) were not contacted due to limitations to access their offices and contact details in the data collection period. Entry contacts to twenty-two (22) institutions were contacted, where we explained the study objectives and asked them to nominate their most appropriate staff that were involved in eHealth implementation or evaluation to participate in the study data collection exercise. Of the twenty-two (22), eighteen (18) institutions responded positively and each nominated staff confirmed to the researchers their respective interview appointments. Four (4) institutions did not respond and did not participate. Verbal consent to participate in the study was obtained from participants, and face-to-face interviews were conducted on separate days at scheduled time at each participant's institution.

The first author (JA) conducted the interviews in English, each lasting between 60 to 90 minutes. Participants' responses were recorded verbatim as written extensive notes. Responses on each question

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were reviewed with each of the participants to ensure that no wrong data was carried over; and more field notes were also written immediately after each interview. Notes taking was used rather than voice recording to eliminate prospective participants' fears that their recorded experiences and opinions might be listened to and evaluated or judged, and this facilitated a relaxed active engagement between the researcher and each participant.

The analysis of the interviews notes was done using the thematic content analysis approach [53] where both authors/researchers (JA and JN) read all the notes to familiarise themselves with the text, then identified codes, and categorised the codes and developed themes from the collected data. Quantitative information about the resultant codes and other quantitative responses were analysed using SPSS (Statistical Package for the Social Sciences) software. Descriptive statistics were generated to produce summary tables and graphs. Feedback on the field findings was then shared with the MoH DHI for review and identification of any obvious outliers in the collected data. The DHI did not identify any outliers and validated the findings to be reflecting the true practices in eHealth implementation and evaluation in the country.

3 Results

3.1 Characteristics of Respondents

Out of the 22 respondents, 17 (77.3%) were males and 5 (22.7%) were females. Most of the respondents 12 (54.5%) were in the age bracket of 31-40 followed by 6 (27.3%) in the age bracket of 18-30 and 3 (13.6%) in the age bracket of 41-50. The respondents included a diverse range of cadres including programme managers, monitoring and evaluation officers, health informatics specialists, software developers, statisticians, and IT systems administrators.

3.2 The Use of eHealth

All participants mentioned that their organisations use eHealth in their health-related activities. With 'great extent' meaning very high rate, 'certain extent' meaning medium rate and 'very small extent' meaning very low rate, 91% of the respondents indicated to be using eHealth to a great extent while only 9% indicated to be using eHealth to a certain extent in their activities. Data collection and reporting (41%) was the most common area of eHealth application followed by data analysis (18%) and others as shown in Figure 1. In addition, DHIS2 (54.5%), mTrac (41%) and Family Connect 5 (22.7%) were reported as the most used eHealth software (Figure 2). Below are some of the participants' responses (quoted verbatim);

> *"We use information systems in basically all of our services provision; stores, general clinic, laboratory, finance and procurement, etc..." (Participant 22)*

> *"eHealth is used to a great extent, for example with the use of DHIS2 to support reporting of routine health services from districts, use of MTrac based on rapid sms for surveillance and medicines management, use of HRIS to manage human resources for health." (Participant 12)*

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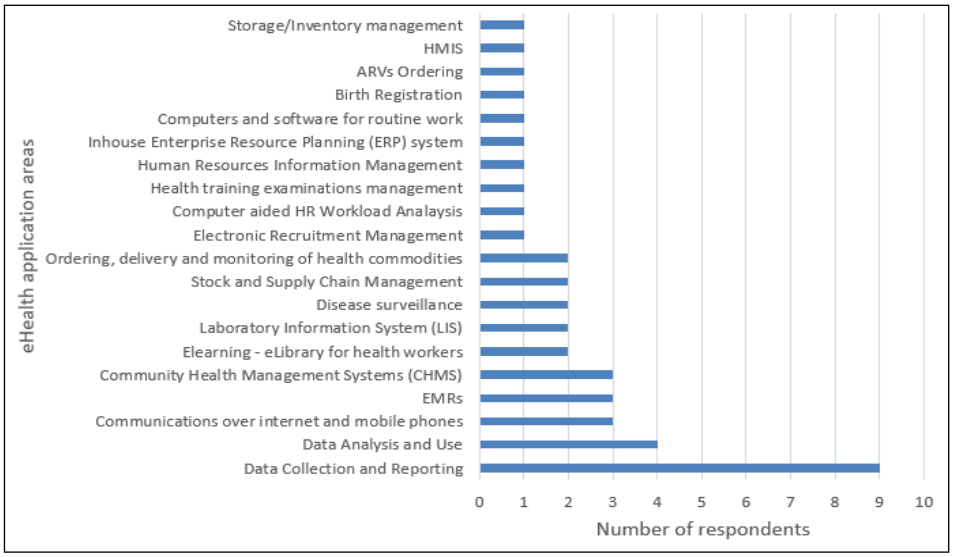

Figure 1: Areas of eHealth Application

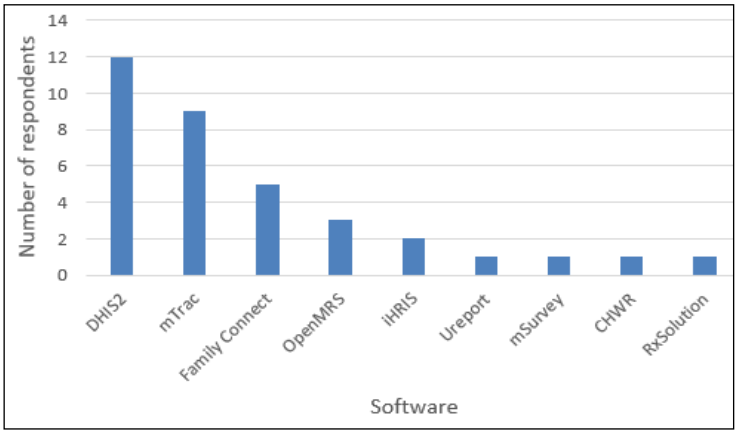

Figure 2: eHealth software in use

3.3 Practices and motivations for eHealth evaluation

Most participants reported that their institutions put efforts to evaluate the performance of eHealth and some organisations do not. 50% of the participants indicated that their organisations put efforts to a great extent, 18% to a certain extent, 23% to a very small extent and 9% not at all into the evaluation of eHealth interventions (Table 1). In addition, 59% of the participants indicated that their organisations use or follow guidance of in-house evaluation tools or adopted evaluation guidelines respectively in conducting their evaluations while 41% do not use or follow any tools and guidelines. For participants who use evaluation tools and guidelines, the reported tools and guidelines included extracts from international standards like principles of digital development (14%), Uganda eHealth policy and strategy (9%), and assessment criteria including indicators and checklists (9%).

On the reasons for conducting the evaluations, checking functionality of the eHealth initiatives was the most reported reason by many participants (32%). Participants reported that institutions also conducted evaluation of eHealth because it was a requirement by funders, to keep track of changes in user requirements, to identify gaps in system functionality, and to streamline partners' approaches to eHealth implementation (Figure 3). Below are some of the participants' responses (quoted verbatim);

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"... I think to a great extent, because we conduct these evaluations throughout the implementation of the systems. We conduct the evaluation because one, it is a requirement from our donors, secondly, evaluations help to quickly document achievements, and also capture user feedback. Internal evaluations contribute to our marketing strategy for the systems." (Participant 2)

".. to a very small extent because we do not normally conduct performance evaluations, but we sometimes want to ensure proper flow of system functionality to meet user requirements." (Participant 17)

Table 1: Extent of eHealth evaluation

Extent of eHealth evaluation	Frequency	Percent
To a great extent	11	50.0
To a certain extent	4	18.2
To a very small extent	5	22.7
Not at all	2	9.1
Total	22	100.0

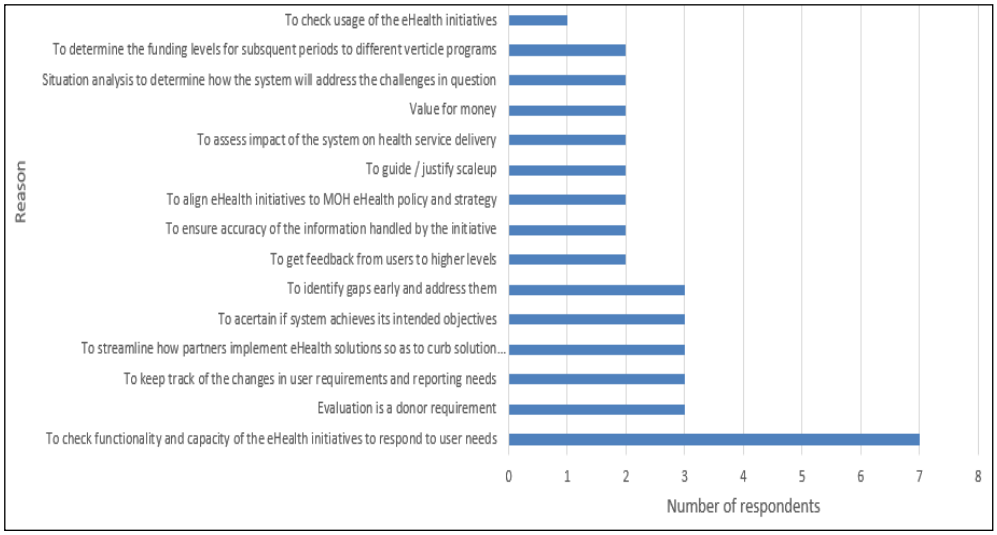

Figure 3: Reasons for evaluating eHealth Interventions

3.4 Indicators monitored during eHealth evaluation

Participants reported various indicators that are currently considered during evaluations, most reported indicators being system availability, system response speed, interoperability, usability, scalability, and availability of human resources to implement the eHealth initiatives (Table 2). Among the participants, 9 (41%) did not mention any indicators because their organisations did not conduct evaluations or they did not have a practice of using indicators for evaluation. Below are some of the participants' responses (quoted verbatim);

"We normally evaluate functional and non-functional requirements of the system. Functional requirements are evaluated through checking the functionality of the system and then validation rules on the data. Then some of the non-functional requirements evaluated are system's

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interoperability capacity with other systems, cost implications for implementing the system, security, scalability, and sustainability of the system." (Participant 6)

"… we only developed the electronic database and dashboard and trained health facility trained staff, and the project even ended but we did not evaluate implementation of the initiative…" (Participant 15)

Table 2: Indicators measured during eHealth evaluation

Indicator	Count	Indicator	Count
System Availability	4	Confidentiality of data	1
System response speed	4	Implementation of data validation rules	1
System interoperability	3	Cost implication on implementing program	1
System functionality	3	Extracts from national and international standards	1
Scalability	3	Ability to support collaboration of end users, partners, Gov't	1
Usability	3	Skills capacity of health workers	1
Staffing levels / (HR Availability)	3	Timeliness of reporting	1
Usage of the system / System use	2	ICT infrastructure	1
Data accuracy	2	USAID Measure tools	1
System security	2	WHO eHealth pillars	1
Sustainability plan	2	Training needs	1
Support for data use	2	Both qualitative and Quantitative	1
Availability of enabling ICT infrastructure	2	Up datedness of the initiative version	1
Number of users of the system	2	Data backup status	1
Data quality	2	Updatedness of data in the system	1
Availability of a champion to lead implementation of the initiative at the implementation site	1	Indicators are always specific to function being evaluated	1
Availability of Audit trail of data changes	1	Work places policies apply to guide on indicators	1
User satisfaction/acceptance	1	Results of performance / quality audit reports	1
Data completeness	1	Quantity of complains from users	1
System accessibility	1		

3.5 Challenges in eHealth evaluation

Respondents reported a wide range of challenges they face during evaluation of eHealth interventions. The most reported challenges and limitations included limited skills/capacity among the evaluation teams, lack of standard procedures on eHealth implementation and evaluation, limited documentation about the eHealth interventions, limited resources in terms of time and money, unharmonised interpretation of eHealth performance indicators and stakeholders' negative attitudes (Figure 4). Below are some of the participants' responses (quoted verbatim);

"We have challenges related to interpretation of evaluation indicators because we do not have them categorised and made more specific, so different stakeholders understand and interpret some indicators differently…." (Participant 2)

".. there is no enough documentation of these initiatives, so trouble comes when individuals leading their implementation leave the organisations where the initiatives are being implemented … evaluating an initiative without enough background information is difficult …" (Participant 3)

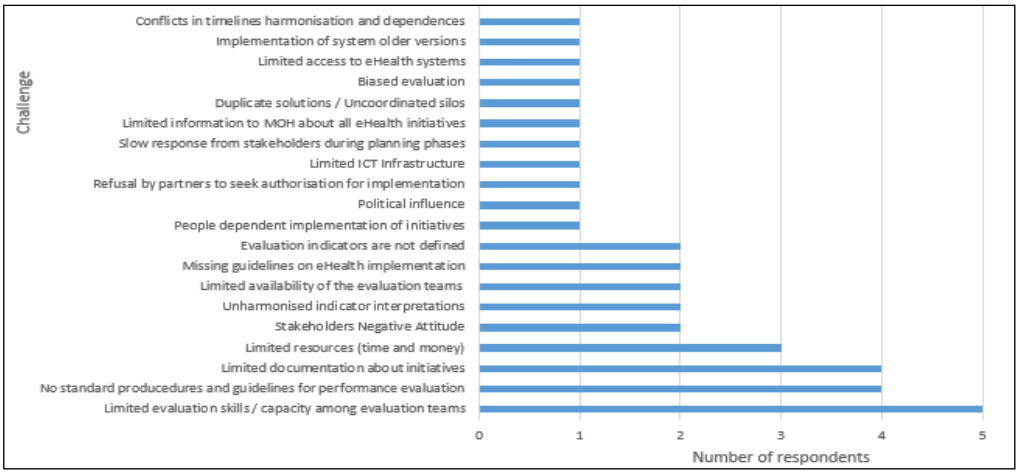

Figure 4: Challenges in eHealth evaluation

4 Discussion

eHealth use and evaluation practices – Results indicated that all the institutions apply eHealth in some ways in the country which is in agreement with [54] [55]. In addition, results indicated various areas of eHealth application although fewer institutions use each; in other words, eHealth implementation in Uganda is not integrated but operated in silos [55]. Regards conducting eHealth evaluation, the results showed that only 50% of the respondents conduct eHealth evaluation to a great extent, while the rest 50% conduct it to a small extent or not at all, implying that there is no concerted culture of eHealth evaluation in Uganda. Looking into the reasons why evaluations are conducted (Figure 3), most of the reasons are related to ensuring proper functionality of the eHealth initiatives. This is also reflected in the indicators measured in Table 2, where system availability, response speed, interoperability, usability, scalability, and availability of human resources to implement the eHealth initiatives are the most measured indicators. The World Health Organization [25] and WHO & ITU [56] categorise such indicators as process and output indicators that provide information and insight on the adoption of an eHealth initiative, are more suitable for monitoring eHealth initiative implementation, and do not necessarily evaluate the performance of the eHealth initiative. This implies that even though more respondents reported to be conducting evaluations on their eHealth implementations, they majorly monitor eHealth deployment, functionality, and adoption rather than measuring the outcome and impact that result from the eHealth implementations. Uganda is not the only country suffering the challenge of having weak eHealth evaluation mechanisms. According to the World Health Organization's observations in its Global Observatory Survey on eHealth of 2016 [4] in which 112 WHO member states participated, though there was a reported rapid growth in implementation of eHealth initiatives in the member states (109, 87%), very few member states (16, 14%) conducted the evaluation of their initiatives. The Eastern Mediterranean region and the South-East Asia region had the highest percentages of countries that conducted evaluations; while in terms of the World Bank income groupings, the high-income countries reported the highest percentage of countries that conducted evaluation of the initiatives [16].

eHealth evaluation challenges – Most respondents reported limited skills/capacity among the evaluation teams, lack of standard procedures on eHealth implementation and evaluation, limited documentation about

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the eHealth initiatives [36], and un-harmonised interpretation of eHealth performance indicators [24]. Other challenges reported by more than one respondent included limited resources (finances and time) to promote eHealth evaluation activities, unavailability of the definition of impact evaluation indicators [38] and stakeholders' attitude about the evaluation [57]. The challenges faced by implementers in conducting an evaluation of eHealth initiatives are more attributed to the fact that the country had no guidelines for eHealth evaluation and implementers had not yet put efforts to building capacity that is relevant for the evaluation of eHealth implementations [37]. Though the country's National eHealth Policy and Strategy [51] was developed and launched in 2017, there were no guidance for all existing eHealth initiatives implemented before 2017. In addition, even when the National eHealth Strategy indicated the need for a monitoring and evaluation framework that focuses on assessing the outcomes and health impact caused by the eHealth initiatives, such a detailed framework and guidelines for evaluating eHealth initiatives in the country were not yet existent.

Insights learned from eHealth implementations evaluation – From this study, we learned that implementers in Uganda undertake more of "monitoring" activities for their eHealth implementations as compared to their evaluation. That is, the implementers understood that such monitoring activities and efforts could also be used to evaluate the impact and contribution of the eHealth implementations to the main programme objectives. This coincides with observations by [58] where only very few cases had their impact evaluation done out of the twelve eHealth cases studied across sixteen African countries. In their study, only Ethiopia's FrontLineSMS and Malawi's CommTrack were evaluated for impact; while for Uganda, both its RapidSMS and MTrac FM were not evaluated. Following guidance by WHO & ITU [56], activities and efforts for eHeath evaluation should consider observations and measurements beyond the process and output indicators to also consider outcome and impact indicators for each of the eHealth implementation/initiative in question. In order to improve the practice of eHealth evaluation in Uganda, efforts are needed to support changing implementers' perspectives on eHealth evaluation; the key effort being the development of an eHealth evaluation framework that will define the notion of "evaluation", its characteristics, and the indicators that should be measured with regards to the performance and impact of eHealth implementations in healthcare and service delivery for Uganda's health system.

5 Conclusion

The researchers investigated the practices and challenges regarding eHealth evaluation in Uganda, and practical weaknesses, challenges and areas of improvement were identified. The study findings can play a vital role in terms of providing the baseline situation on which health leaders and policymakers as well as the eHealth implementers can set improvement targets and action plans for strengthening and sustaining eHealth in Uganda. Accordingly, following the guidance of the national eHealth policy and strategy, there is need for the development of an eHealth evaluation framework, evaluation indicators and guidelines for using such a framework, which then can be used to evaluate the outcome and impact of eHealth interventions in the country. Additionally, we advocate for the creation of awareness of the need to plan for eHealth evaluation in addition to monitoring activities during the planning of eHealth implementation programmes. The authors/researchers are already using insights from this study to inform the development an eHealth evaluation framework that will guide comprehensive evaluation of eHealth interventions in Uganda. We recommend future work to include an investigation about other important attributes related to eHealth evaluation activities such as who are the evaluators / offices responsible for conducting eHealth evaluation, and their required skills, the process of agreeing on evaluation data collection tools, among others.

Acknowledgements

We would like to acknowledge all the respondents who participated in our field investigation study particularly the Ministry of Health, Uganda (Division of Health Information), eHealth TWG members, Health Development Partners and eHealth implementers in Uganda.

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Journal of Health Informatics in Africa

Factors that Influence Potential Success of eHealth Standards Adoption in a Low- and Middle-Income Country: a review

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Background: Assessing the potential success of adopted technology, innovation, or standard in a Low and Middle-Income Country like Uganda continues to focus on outcomes of adoption. This study aimed to investigate the potential success of eHealth standards adoption that may arise from the adoption process as well as outcomes of such adoption.
Methods: PubMed and Google Scholar were searched using alternate terms for "eHealth", "standards", "adoption" "success" and "theory". On screening and assessing the quality of publications, only nineteen peer-reviewed publications were included in the review. Both quantitative and qualitative analysis was used to synthesize evidence from the included literature. Thematic analysis was used to develop themes regarding the success of standards/technology adoption.
Results: Constructs from the theories of Diffusion of Innovation Theory (DOI), Unified Theory of Acceptance and Use of Technology (UTAUT), and Internet Standards Adoption (ISA) were used to extend the Success Model of Innovation Adoption. The Success Model for Innovation contributed to the foundational concepts aligned to categorical factors of the adoption process, organizational, environment, and user context that influence the potential success of eHealth standards adoption in healthcare systems. The study identified 13 factors that contribute to the successful adoption of standards for eHealth.
Conclusion: Since the review showed that success of standards adoption starts with assessing readiness to adopt the standards, followed by the standards adoption process and assessment of the lasting outcomes, the study proposes a model for assessing the potential success of eHealth standards adoption. The model has pre-adoption, actual adoption, and post-adoption phases. The proposed model and identified factors have not been evaluated and therefore may not in the current form support eHealth standards adoption processes. Future work is needed to evaluate/validate the model and factors of eHealth standards adoption success. Notwithstanding, the study believes any assessment of the success of standards adoption that uses the identified factors over all three phases of the model is comprehensive to present a true picture of any potential success of standards adoption.

Keywords: Adoption Success, Standards, eHealth standards, LMIC

1 Introduction

Low- and Middle-Income countries (LMICs) including Uganda have realized that the adoption of ICT in health (eHealth) can alleviate their healthcare resource challenges. To benefit from eHealth, it is essential to develop the right infrastructure [1]. Inappropriate infrastructure causes a reduction of speeds which is claimed to be the most important factor of adopting eHealth technologies [1]. But many countries continue to prioritize the allocation of their limited resources to other domains of healthcare interventions over the Information and Communication Technologies (ICT) domain [2], [3]. eHealth implementation in LMICs continues to be plagued by inadequate resources. Despite efforts by the World Health Organisation (WHO)

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 J Health Inform Afr. 2020;7(1):24-37. DOI: 10.12856/JHIA-2020-v7-i1-274

to guide eHealth adoption in LMICs, these countries have continued to lag behind High-income countries in their adoption of ICT to support healthcare.

Scholars have identified various challenges to eHealth adoption in LMICs to include high operational cost of eHealth technology, maintenance cost of the eHealth infrastructure, poor internet connectivity especially in the remote areas of LMICs, unreliable electric power supply, and human resource /technical expertise on use of eHealth technologies, among others [2], [4]–[6]. These, including lack of standardization, are infrastructural and organizational challenges that negatively affect the implementation of standardized eHealth technologies to support Health Information Exchange (HIE) in LMICs [7]. Besides, the success of eHealth in LMICs has been hampered by technology challenges like fragmented and proprietary implementations of technologies [8], [9] that results in lack of interoperability of systems, organizational issues and user concerns [8] such as the clinical and economic impact of the eHealth intervention, security and privacy concerns of the use of eHealth technology.

Studies show that existing eHealth implementations in LMICs are characterised by fragmented systems that are unable to share or exchange health information [10], [11]. To achieve the benefits of eHealth in LMICs, existing and future electronic systems must be interoperable. Interoperability is the ability of health information systems to link within and across healthcare organizations, understand each other and use the functionality of each other [12], [13]. ITU [13] argues that standardization is the most critical driver of interoperability. Therefore, the adoption of eHealth standards that support interoperability should be coordinated at all healthcare. In fact, for interoperability to happen, the eHealth systems and technologies must share a common standard [13], [14].

Boore et al. [15] argue that "standardization is one of the most important issues for the successful development and deployment of eHealth systems since many standards are developed independently of the organization originally preparing the standard". Furthermore, Payne [5] recommends that LMICs should "adopt standards for interoperability during the formative period of the ICT infrastructure and health informatics ecosystem". So far LMICs have made little progress to adopt standards for eHealth [15]. Even though various LMICs have identified the need for standardization in their eHealth strategies and policy documents, with clear benefits of adoption, the eHealth standards have not yet been adopted. The slow progress on adoption of eHealth standards are attributed to little participation in international eHealth standards development, lack of a formal standardization process suitable for LMICs to adopt standards for eHealth, unregulated penetration of eHealth systems, delayed eHealth standardization efforts and resource-related challenges among others [6], [7], [16]–[19]. According to Feroz *et al* [3], WHO claims that health systems fail to successfully adopt eHealth technologies due to lack of readiness among healthcare organizations, providers, and communities. A previous study on the adoption of standards for eHealth communication infrastructure [20], developed an assessment framework with 16 metrics for assessing the readiness of health systems in LMICs to adopt standards for eHealth. A readiness assessment helps identify barriers to the successful adoption of a new artefact [6]. Just like perceived benefits of adoption of innovation is a facilitating factor in the adoption of IT by healthcare professionals [21], [22], this study was done on the premise that eHealth standards adoption can also be motivated by the likelihood to realize the lasting benefits of such adoption. Thus making the benefit of the adoption a measure of the success of such adoption.

This study was motivated by the realization that there is no study on success factors of eHealth standards' adoption, presenting a challenge to the successful adoption of eHealth standards by LMICs. Studies have argued that the success of any adoption of a technology artefact is dependent on process, user context, organizational context and community context [23]–[25]. These are informed by several technology/standards adoption theories/models as discussed in the review of theories in Section 2.

Therefore, the study aimed to explore factors of potential eHealth standards' adoption success in LMICs like Uganda. To achieve the objective of the study, the following research questions were explored;

(i). How can the success of eHealth standards adoption be conceptualized?

(ii). What are the major success factors that influence eHealth standards adoption especially in LMICs?

Noting the lack of evidence on studies focused on the success of eHealth standards' adoption, we sought to answer the first question of conceptualizing the potential success of standards adoption. Therefore, the study reviewed four technology/standards adoption theories considered appropriate to inform our study of the potential success of standards adoption.

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2 Literature Review: Theories to inform eHealth Standards Adoption Success

In this section, we review theories that informed our conceptualization of the success of eHealth technology/standards adoption. The study reviewed three technology adoption theories and one standards adoption model i.e. Unified Theory of Acceptance and Use of Technology (UTAUT), Diffusion of Innovation (DOI) Theory, Success Model of Innovation Adoption, and Internet standards adoption (ISA) to conceptualize the dimensions for successful adoption of standards for eHealth in Uganda's healthcare system. These theories were chosen on the basis that they are technology adoption theories or standards adoption models that discuss the process, user, organizational, and community contexts; and or success factors for IT artefact adoption.

2.1 Unified Theory of Acceptance and Use of Technology (UTAUT)

Venkatesh *et al* [26] conceptualized user acceptance of new technology to include intentions to use the technology, individual reactions to using the technology, and actual use of the technology (see Figure 1:). The authors identified four antecedents of the acceptance of information systems. These significant constructs are effort expectancy, performance expectancy, social influence, and facilitating conditions. These were developed from fourteen initial constructs derived from eight competing acceptance theories including the diffusion of innovation theory [26]. Besides, they identified four significant moderating variables that include gender, experience, age, and voluntariness of use.

This study applied UTAUT to explore factors that influence acceptance of eHealth standards in the following ways;

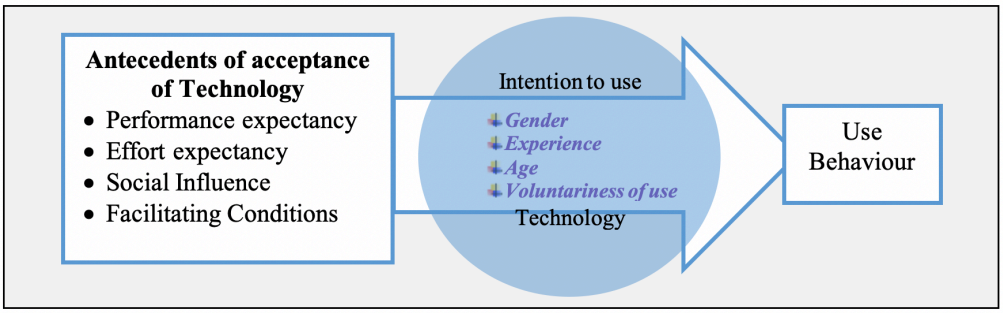

Figure 1: Constructs in the UTAUT [26]

(a) Performance expectancy is the degree to which an individual believes that using the system (in this case standardized eHealth system) will help attain gains in job performance [26]. This was developed from other constructs such as perceived usefulness for Technology Acceptance Model that lends to the study of the use of standards in eHealth setting accounting for its success.

(b) Effort expectancy refers to the degree of ease associated with the use of the system [26]. In the context of a standard, it should refer to ease of interpretation (ease to understand) and implementation of the standard. Signifying the standards is not too complex to understand by implementers/users and therefore can be successfully implemented. These greatly affects the first use of standards but becomes less significant with continued use of standards by health care organizations.

(c) Social influence is the degree to which an individual perceives how others view their use of new technology [26]. The perception that others positively view the use of a new system encourages the user to apply it more. This study believes that positive perception of the adoption of eHealth standards will encourage use both internal and across healthcare systems resulting in success form such standards adoption. The role of social influence in technology acceptance decisions is complex and subject to a wide range of contingent influences [26] that may also be true for acceptance of eHealth standards further reducing any possible success.

(d) Facilitating conditions refers to the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system [26]. With support from WHO, many LMICs including Uganda have developed national eHealth strategies and policies [27] to guide the adoption of eHealth. Among the strategies is the need for contextualized standards for eHealth.

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However, infrastructure for eHealth continues to experience challenges [4], [6] as previously enumerated presenting a negative facilitating condition for eHealth standards implementation. The resource component such as limited resources to participate in global standards development [4], [17] continues to be a big hindrance to eHealth standards adoption in LMICs.

The intention to use technology relates to user characteristics such as gender, experience, age, and voluntariness of use. Similarly, the use of adopted standards is influenced by these user characteristics that have a significant influence on user behaviour.

2.2 Diffusion of Innovation Theory (DOI)

To understand the concept of success in the adoption standards for eHealth, the study adopted the Diffusion of Innovation Theory (DOI). Diffusion is the process where adopters become aware of the standards over time and consider it for adoption [28]. DOI is a process that occurs as people adopt a new idea, product, practice, and philosophy [29]. The process begins with an initial few who adapt to the use of innovation, technology or standards, then with the increase in their perceived usefulness and perceived ease of use, more people and organizations are driven to adopt its use. Whereas DOI covers the technological context (all technologies that are relevant to the organization), characteristics of an innovation (attributes that determine the rate of adoption) [30], and adopter characteristics (degree of being early or late adopters of innovation) [28], [31]; this study focuses on the innovation-decision processes i.e. the stages through which an individual or a decision-making unit passes, that is, from initial knowledge of an innovation to its adoption or rejection and a final confirmation of such decision [28] as seen in Figure. Adoption success depends on the adopter's capacity to follow the rigorous stages of diffusion, also known as the innovation-decision process [24]. In this regard, the success of eHealth standards adoption requires rigour in the decision process by eHealth stakeholders.

In the innovation-decision process, at first, an adopter organization (Uganda's health system) becomes aware of the existence of the standards. Any lack or incomplete knowledge about standards may mean suitable standards are not adopted. In the second stage, decision-makers of the adopter health systems may need to get persuaded about the importance of such standards since lack of knowledge may mean such standards are not recommended for adoption. The third phase allows the adopter to visualize the present and future standard environment and decide to experiment or not with the standard. This is followed by the full use of the standard at stage four, and lastly, a final decision to continue with the use of the standard, review it or discontinue its use at stage five. The existence of such a structured adoption decision process within the adopter health system may provide a significant measure of their readiness and potential success in adopting standards for eHealth.

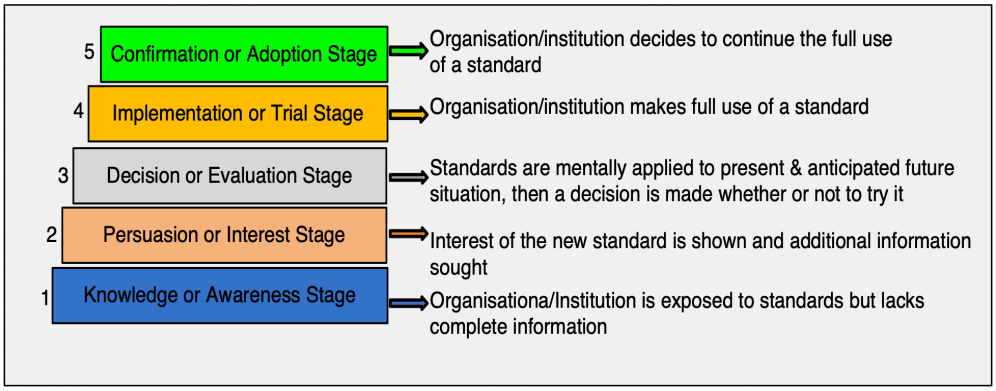

Figure 2: Relating Stages in the DOI to eHealth Standards Adoption

In addition to the decision to adopt a standard, the organisation needs to apply and continue the use of the standard [24]. It is useless to adopt the standards (post-adoption behaviour) if it cannot be put to the proper use. The use completes the adoption process. According to Leonard [32] the factors that can be used to measure the duration of the effects/influence of adoption include the amount of training before and during

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transitions, the amount of resistance to change or industry experience in using technology or innovation, the amount of buy-in (or contribution) from stakeholders, the level of reporting on the outcomes measured during and after implementation of standards, and the level of effectiveness in dealing with the "breaks" (i.e. gaps between the introduction of and full use of the standard, a period when implementers seem reluctant to commit to the changes caused by the new introduction).

A huge disadvantage of using DOI to aid the adoption and diffusion of eHealth standards in fostering stakeholder participation. Kiwanuka [23], argues that DOI is not likely to be a strong predictor of adoption readiness in situations where adoption is compulsory; consequently, we use concepts from DOI to develop a model for assessing eHealth standards adoption success in Figure .

2.3 Internet Standards Adoption (ISA)

According to Hovav *et al.,* [33] standards adoption is represented by the ISA model (see **Error! Reference source not found.**) as a function of the utility of the standard's characteristics (individual perspective) and the environment in which the adopter operates (community perspective). The ISA framework acknowledges that besides the features of the standard having high utility (useful features), successful adoption requires an adoption environment that is conducive [33]. Both dimensions must be of high quality for the standard to be fully adopted and low quality for the standard to be rejected by an organization. It should be realized that the useful features of a standard may appeal differently to potential adopters. Although the ISA exhaustively explores the adoption of environmental influencing factors such as adoption by other organisations and a large base of existing or related technologies, it does not consider other factors that may infulence successful adoption. Therefore, it can only complement other contributing factors of successful standards adoption.

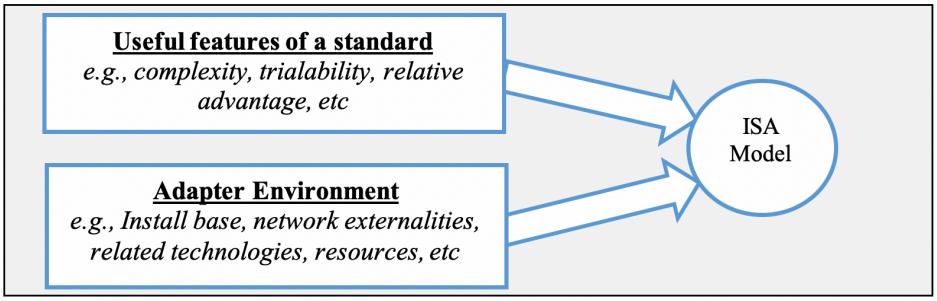

Figure 3: Model of Internet Standards Adoption [33]

Useful features of the standard that are considered by the ISA model informs the standards adoption process guiding the standards selection process. Only applicable standards need to be adopted and or contextualized. Also, the adopter healthcare system can contextualize standards to their needs (based on unique functional requirements) as advised by Payne [8].

The adopter healthcare environment represents the community context for the implementation of the standards. For a successful implementation and collaboration among eHealth standard implementation organizations, there is a need for a broad base of implementers, available resources to support standards implementation, and a supportive network of technical personnel to advise on implementation and monitoring of compliance among others [34].

2.4 Success Model of Innovation Adoption

Rajiv & McLean [24] introduces two constructs of the success of adoption of IS innovations (see Figure). One, "*success of adoption*" that deals with the success of the adoption process itself. Two, "*success from adoption*" that deals with any form of success from adoption outcomes. Their conceptualization of the full scope of success starts from the adoption process and extends to the outcomes of such adoption. To them, IS innovation adoption process is successful when innovation is successfully adopted and used by most, or all, of the adopting units within the community of potential adopters. The community of users consist of a

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community of practice/network externalities, that collaborate and or support each other in the implementation of an IS system. In this case, would be the implementation of eHealth standard.

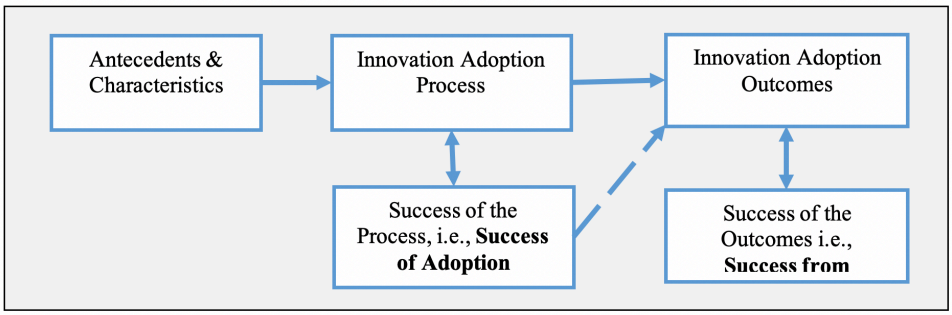

Figure 4: Success Model of Innovation Adoption [24]

However, this study argues that successful adoption in the complex healthcare environment starts with proper preparation before adoption, that is the preparations to adopt a standard. The problem owner's early involvement in problem identification and scoping, identification of the requirements/need for a standard cannot be forgotten as a factor of success in any IS/standards adoption. Success should include consideration of the positive antecedents and characteristics of a health system readiness to adopt standards. Therefore, the study identified this as a construct that is missing from the success model for innovation adoption.

Besides, the success of any innovation is also dependent on its diffusion and infusion [24]. They argue individual adopter organisations must adopt the innovation (diffusion) and that infuse highly amongst individual members (infusion) for success to be measured. Satisfaction with innovation is related to the diffusion of innovation construct of perceived usefulness or relative advantage and infusion are assessed by evaluating the scope of use and intensity of use of an innovation [35]. These concepts of diffusion and infusion of artefacts are also missing parts of the Success Model of Innovation Adoption that is addressed by the proposed Success Factor Model for eHealth Standards' Adoption in Figure 6.

2.5 Contextualizing Success Factors for eHealth Standards Adoption

There exists no single technology/ standard adoption theory to explain the successful adoption of eHealth standards. Borrowing from the discussions of other authors, that argues that success of any artefact adoption depends on the adoption process, the user of such adopted artefact, the organizational context of deployment, and community of practice [23]–[25], this study conceptualized context of the success of eHealth standards adoption (see Figure 5).

To answer the question of conceptualization, the study likened standards adoption to technology adoption. Just like any new technology/innovation, the challenges to adoption of a new artefact are similar across different organizations. Therefore, embracing the dimension of adoption success as applied to eHealth technologies standards adoption is dependent on the success of the adoption process, the organizational context, user context, and community context [3], [24]. The determinants presented in Figure 5 are described in the categories of;

(a) *Adoption process*: Standards adoption success depends on the capacity of the health system to follow the rigorous stages adapted from the diffusion of innovation theory, known as the innovation-decision process [24]. The involvement of healthcare stakeholders in the process of standards adoption reflects the broader inclusion of their expectations of ICT in health and a greater possibility of acceptance of the outputs of the adoption team. It should be realized that the adoption process is influenced by the resource capacity of the adopter organization. A limited resource setting may impact the type, quality, and suitability of standards adopted.
(b) *Organizational context*: Both public and private healthcare organizations play a key role in any healthcare system [2]. Similarly, their role is to align the eHealth standards' needs to respective national healthcare policies, such as Uganda's national eHealth strategy and policy [27]. Successful contextualization of global eHealth standards to a country's needs is, therefore, their responsibility.

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(c) *Community Context*: This is a group of healthcare organizations or health facilities that collaborate in the provision of healthcare. Just like with technology, the willingness of eHealth users to uptake and adhere to standards for eHealth may be slow. Therefore, it is the responsibility of the adopter community to collaboratively enforce implementation and monitor adherence with the agreed-upon standards for eHealth.

(d) *User context*: Just like with technology/innovation adoption success, where user acceptance and use of technology is the most important factor of success [22], acceptance of the use and adherence to standards contribute to the successful adoption of standards [21]. When introducing eHealth standards, the goals and aims of healthcare providers should be incorporated for them to adapt to the use of such standards

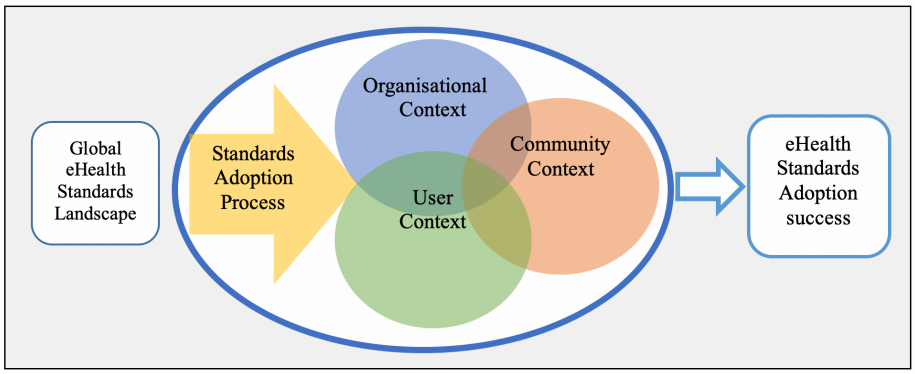

Figure 5: Contexts that Contribute to the success of eHealth Standards Adoption

The relationship between the standards adoption/ contextualization process, the organizational policies, healthcare stakeholders' roles as a community of implementers, and user context is a predictor of the standards' possible success. Therefore, the study assumed that the four determinants represent dimensions of success of eHealth standards adoption in resource-constrained settings like Uganda's health system.

3 Methods

A structured review of the literature was done to identify success factors that influence the adoption of eHealth standards/technology. At the start of the study, we consulted seven eHealth stakeholders drawn from the Ministry of Health, Ministry of ICT, Uganda Bureau of standards, four top health system levels in Uganda. The decision was influenced by the research field, that these stakeholders represent the views of problem owners and therefore helped identify pertinent issues to the success of eHealth in Uganda. The stakeholders helped conceptualise the context of success in the adoption of eHealth standards. They refined the objectives to focus the study proper preparation mapping, adoption process, and standards adoption outcomes.

Search strategy: To perform a full search, articles for this review were gathered from PubMed and Google scholar. The choice of PubMed and Google scholar is based on the argument that one, they provide free access allowing researchers to retrieve full papers of all relevant publications. Two, almost all (very percentage) health informatics publications are indexed in PubMed. Since 91% of all PubMed content is indexed in MEDLINE the database of all medical publications and a study by [36], reveal that a combination involving MEDLINE and Google scholar can achieve a recall of not less than 98.3%. Therefore, the study believes that these two databases are suitable to retrieve relevant literature regards factors that influence potential eHealth standards adoption. The search strategy included three categories of keywords: (i) "adoption" OR "adoption success"; (ii) "electronic health" OR "e-health"; and (iii) "standard" OR "technology" OR "innovation". Synonyms of the keywords were used to perform an exhaustive search of relevant literature.

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Study Selection and Data Extraction: An article was included if it satisfied the inclusion criteria: (1) peer-reviewed publication in English; (2) has a full-text status; and (3) discusses success factors or enables of technology/standard adoption and or implementation in health. Evaluation of the success factors is not a requirement for inclusion. After removing duplicates, the studies were screened for inclusion/exclusion, and only nineteen peer-reviewed publications remained to be used in the extraction of information that was used in the analysis.

The following information was extracted into a spreadsheet: first author surname and year of publication, type of study, type of study country, theory/model/standard, constructs of the theory/components that guided the study, success factors that inform/influence successful adoption/contextualization of standard, and for the standards: where they have been implemented, and results of success (if evaluated). Analysis qualitatively explored the concept of eHealth standards adoption success and success factors of eHealth standards adoption.

4 Results

To answer the two research questions, data from papers that were included in the review were extracted into a spreadsheet. Three phases of eHealth Standards Adoption success were considered.

First, to answer the question of how to conceptualize the success of eHealth standards adoption, the study identified constructs of technology adoption theories as used to assess the successful adoption of technology. This study adopted the Success Model of Innovation Adoption [24] as its foundation model for the development of the success factor model for eHealth standards adoption (see Figure 6). Constructs from UTAUT [23], DOI [24], and ISA [33] were used to extend the Success Model of Innovation Adoption.

A summary of the constructs and pre-conditions to successful adoption of eHealth artefacts is presented in Table . Various applications of technology adoption theories to assess success have used organizational, human, technological diffusion/infusion constructs. Besides, these studies recommend readiness assessment, adoption process, organizational and user acceptance and use as conditions to successful adoption of eHealth artefacts.

Table 1: Constructs for Assessing Successful Adoption of eHealth Artefacts

Constructs of the theory that inform successful adoption of eHealth artefacts	Success Requirements	Pre-conditions for Successful Technology/standards adoption
• **Organizational, facility or community dimension [2], [3], [7], [21], [28]–[30], [37]** • **Human/User dimension [2], [21], [26], [37]** • **Technological context [21], [26], [29], [30], [37]**	• Diffusion and Infusion [23], [24], [28], [35], [38]	• Readiness assessment focusing on health system as organisation, availability of the resources, willingness of healthcare providers and users [3], [6], [20] • Adoption environment and or adoption process [24], [33] • Characteristics of the technology/standard [33] • Organisations' acceptance [2] • User acceptance and use [26]

The authors used identified constructs to study the adoption of eHealth artefacts in the ratio of 47%, 24%, and 29% of the time organizational, human dimension and technological respectively. To attain full benefits of the eHealth artefact, then the technology, innovation, or standard must diffuse and infuse into the healthcare work practices of the health system. Besides studies have explored various pre-existing conditions that influence the success of technology/standards adoption. The identified constructs were used to develop the model in Figure that can be used to assess the potential success of eHealth standards adoption.

Standards adoption success or worthiness can be determined by assessing the standards adoption process and outcomes. The adoption process starts with a proper assessment of the readiness of a health system to adopt standards for eHealth (the pre-adoption phase) followed by actual adoption processes. Comprehensive assessment of standards adoption success can be measured, One, by assessing readiness to adopt standards. Two, the adoption phase where the success of adoption and use of innovation by most, or

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all, of the adopting units (*success of adoption*) is evaluated. Three, the post-adoption phase where the potentially lasting effects/benefits of innovation by the adopting units (*success from adoption*) are measured.

Pre-adoption phase – potential success is possible if a health system is ready to adopt standards for eHealth, i.e., the assessment shows positive antecedents and characteristics of a health system readiness regards the characterizes of the standards, the adopter health system, and the implementation environment. Gesulga [6] argued that readiness assessment as the most important step before implementation and an essential requirement for the success of an eHealth artefact in terms of adoption rate or acceptance. Exploring the readiness of the health system is essential for the successful adoption of eHealth technology [39]. i.e., eHealth artefacts and in this case standards for eHealth. In our previous study, we proposed several metrics for assessing the readiness of a health system to adopt standards for eHealth communication infrastructure [20] that cover the broad dimensions of standards characteristics with six metrics, adopter health system (five metrics), and the standard implementation environment (five metrics).

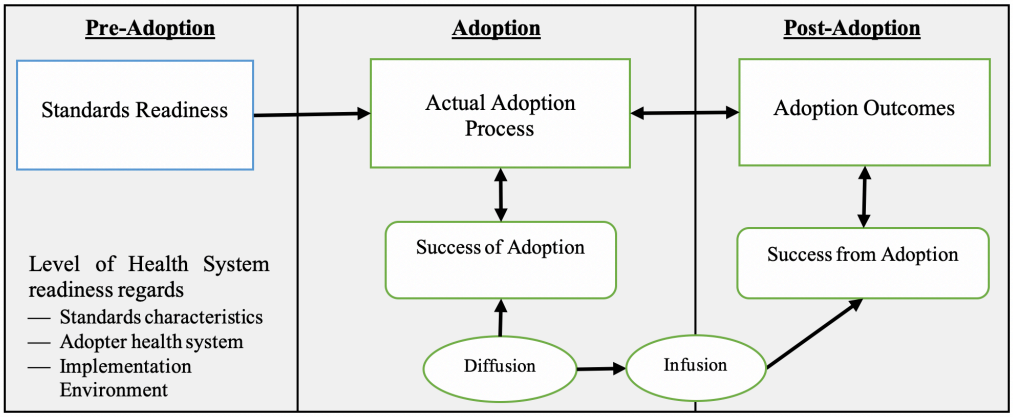

Figure 6: Adaption of Success Model of Innovation Adoption to Success Factor Model for eHealth Standards Adoption

Adoption Phase – is where actual meetings and decisions are taken to select/contextualize particular standards. The adopter organization becomes aware of the standard over time, their possible usefulness, and consider it for adoption (*the diffusion process*) [28]. Rogers [28] identified five characteristics of innovations that influence the decision to adopt or reject it including relative advantage, compatibility, complexity, trialability, and observability. Besides diffusion which [38] termed unprogrammed knowledge transfer, the success of adoption also depends on the infusion. Infusion is deliberate knowledge transfer with three dimensions of the intensity of usage, the scope of usage, and satisfaction with the innovation [35]. To realize the benefits of eHealth standards, the health system as an adopter organization needs to sensitize its relevant stakeholders and involve them in the decision process to select, deploy, and use the standards. This involvement contributes to satisfaction (high or low) to use the innovation/standards by the majority of involved stakeholders [35]. Infusion contributes to both successes of adoption and success from adoption.

Post-adoption Phase – focuses on the outcomes of adopting standards. At this phase success is a measure of the positive outcomes and is influenced by resistance to change, level of reporting on the implementation of standards, and how the implementer organization deals with the "breaks"[32]. Other factors include the presence of other users that can support the use of the standard [21], and the level of management of the implementation [21], [34] among others. These factors span the scope of community and individual user contexts.

4.1 Potential Success Factors of eHealth Standards Adoption

Second, to answer the question of what are the major success factors that influence eHealth standards adoption, the review used constructs of the adoption process, user context, organisational context and

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community of user context (as identified from the technology/standards adoption theories and success of innovation adoption) to identify and categorize potential success factors as summarised in Table. There exist seven factors that relate to the eHealth standards adoption process (Success of Adoption) and six factors that influence eHealth standards adoption outcomes (success from adoption).

As reported by Gagnon et al [17] various studies, perceived usefulness is reportedly the most frequent adoption factor. This includes ease of use, design, compatibility, and cost among others. Skills and training factors cover know-how, familiarity with the breadth of system functionalities, and other user contextual factors like age, gender experience, and willingness to use the system. Stakeholder participation is another core factor in the success of any innovation and standard. Lack of participation may mean their interest are not factored in, or little understanding of the usefulness and failure to accept (buy-in) use of the standard. Ease of use or amount of resistance to change or industry experience in using standards for technology or an innovation [21], [24], [34] is a factor considered relevant to the success of eHealth standards adoption. Additional factors that pertain to the success of standards adoption are technical aspects like ease to understand or complexity of the standard, compatibility, required material resources required to aid the adoption process [21], [34]. It may be necessary to understand the complexity, compatibility before adopting. This can be achieved during the standard pre-adoption assessment.

Table 2: Success Factors for Potential eHealth Standards Adoption

The dimension of success factors		Success factors
• **Adoption Process** • **User context**	Success of Adoption	• Perceived usefulness [1], [2], [21], [22], [26] • National policy [2] • Amount of training before and during transitions [2], [21], [24], [26], [32] • Amount of buy-in (or contribution) from stakeholders [1], [2], [7], [21], [22], [24], [32] • Amount of resistance to change or industry experience in using standards for eHealth, technology or an innovation [21], [22], [24], [26], [32], [34] • Technical aspects such as complexity, compatibility, needed material resources, etc [21], [34] • Features and characteristics [30]
• **Organizational context** • **Community context**	Success from Adoption	• A clear strategy and organizational process [7], [37] • Level of reporting on the outcomes achieved during and after the implementation of standards [24], [32] • Level of effectiveness in dealing with the “breaks” [24], [32] • Leadership and management of the implementation [7], [21], [32] • Resource factors (human resources, financial, infrastructural and technical resources) [1], [2], [21], [26], [34], [37], [37] • Network externalities and external environment, i.e., presence of other users [2], [21]

Regards the success of adoption, six major factors that may influence the success of technology adoption as identified from the literature were considered relevant to explain the success of standards adoption. They are largely managerial and exist both at organizational and community levels. These include strategies and organizational processes to direct implementation and compliance to standards, reporting of achieved outcomes, how to deal with any breaks, enforcement/management of the standards implementation plan, a network of the user organizations that can support use, and policies on resources required to support pre-adoption, adoption, and post-adoption activities of the standard. Also, there are organizationally engineered facilitating conditions like infrastructural resources, technical financial and human among others that support eHealth standards’ adoption and use by participating stakeholders.

Authors have differently identified or referred to the success factors for the adoption of technology/standards for eHealth. The graph in Figure shows several references to factors that influence the successful adoption of eHealth technology/artefacts in the reviewed literature.

The graph shows that amount of stakeholder buy-in and supportive resource factors have been identified as the highest influencers of successful adoption in several studies. Second, is resistance to the use of the

new technology. Third, is perceived usefulness and required training on the use of the new technology/standard. Forth, is leadership and management. Fifth, are network externalities, level of effectiveness dealing with breaks, level of reporting, clarity of implementation strategy and organizational process, and technical aspects. Sixth, are feature and characteristics of the technology /standard, and national policy regard adoption of the eHealth technology/standard.

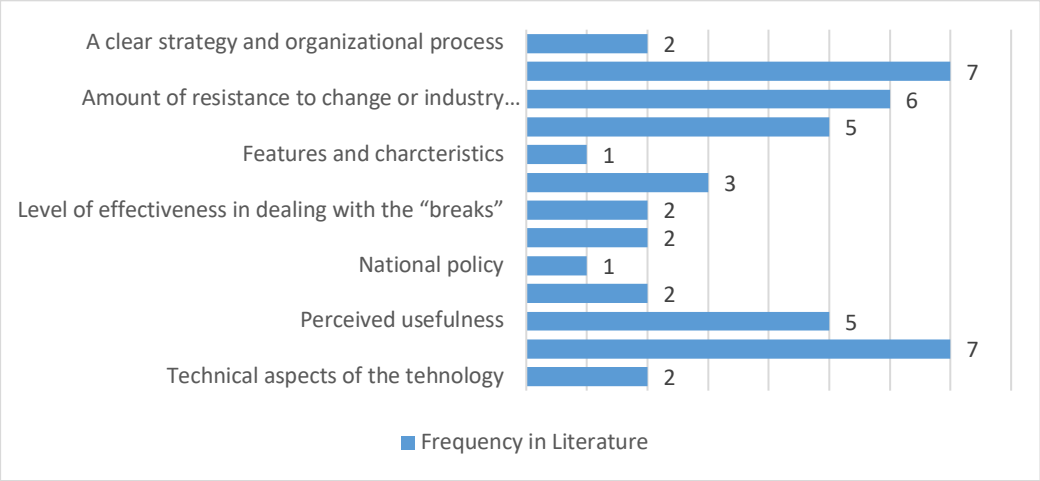

Figure 7: Frequency of Success factors of Adoption of eHealth Technologies

5 Discussion

Successful adoption and use of any technology or standard depend on success at each phase of adoption or implementation [37]. Unlike Rajiv and McLean [24] who suggest that the adoption success should start either at the adoption process level or the adoption outcome level, we argue that the overall standards adoption success should integrate readiness assessment with both levels of adoption process and adoption outcome as illustrated in Figure , creating a model for assessing the potential success of eHealth standards adoption. The model has the pre-adoption, actual adoption, and post-adoption phases. A comprehensive measure of success cannot be done in isolation of any of these phases. While pre-adoption concerns itself with standards readiness, the actual adoption process focuses on the decision process, that is, possible delays in buy-in and or resistance to change by decision-makers, to fail the adoption process. The amount of training before and during transitions, that is, standard user support, can improve the use of the standard. Adoption outcome assesses the level of reporting on the outcome measured during and after implementation (communication on the technology adoption progress) and level of effectiveness in dealing with the "breaks" can both improve adopter understanding of the standard and its impact, hence support the monitoring and review process. Similarly, overall, standards adoption success is dependent on the accomplishments of the pre-adoption phase. A health system with established antecedents and characteristics (readiness to adopt standards for eHealth) for standard adoption and follows the due process of adoption is more likely to succeed in adoption.

On one hand, the success of adoption arises from the standards adoption process. Adopters are motivated by their view of the perceived usefulness of the standards [21] that relate to the performance expectancy of UTAUT [26]. Interest can be initiated via training on the need and usefulness of standards. Training can ensure that the adopter organization, user community, and the individual users are convinced of the benefits of the standard, build confidence in the use of a standard, or gain control and are efficient (that is, optimism in use of standard). This increases the possibility of successful adoption of eHealth standards. Training health workers and stakeholders in Uganda's health system will enable them to appreciate the benefit of adopting/adhering to standards for eHealth. Training and orientation in using the standard or industry experience in using related standards can reduce the amount of resistance to the adoption of the standard for eHealth, their technology, or innovation. Furthermore, increased buy-in implies an increased number of

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stakeholders, wide implementation, and a broad base of collaborating partners using the standards; this becomes a possible enabler of successful adoption of the standards.

The dimension of success from adoption is a consequence of the adoption process [24]. As much as positive results cannot be expected from the failed adoption process, success from adoption follows after the success of adoption by measuring the level of reporting during implementation and level of effectiveness when dealing with breaks. The standards adoption process can be considered successful by Uganda's Ministry of Health only when adoption outcome (post-adoption behaviours) include compliance with the use of the standards.

As shown, many dimensions and factors influence the success of standards adoption. The dimensions of success factors are overlapped as was depicted in Figure 5, and therefore some of the factors overlap the dimensions of successful adoption of standards. For example, the resource factors can be an organizational policy issue on one hand and the other hand stakeholder training is required to sensitize them of the need, purpose, and benefits of adopting standards, or even user training on the use of the standards. The identified factor has been differently emphasized by the authors. The graph in Figure revealed that studies have emphasized 6/13 factors above all others signifying they are high influencers of successful adoption of eHealth artefacts. Besides, the six factors relate to artefact acceptance due to perceived usefulness, training stakeholder involvement and availability of resource factors like finances, infrastructure leading to reduced resistance to the new introduction of an eHealth artefact, standard. These factors span the breadth of organizational, human and technological dimensions of the technology adoption theories. In this manner, the study of successful adoption of eHealth standards conforms to principles of technology adoption theories.

6 Conclusion

Motivated by the realization that to date, other studies have not explored the concept of successful adoption of eHealth standards, this study reviewed the literature on the success of technology/innovation adoption and applied it to standards adoption. Conceptualization of eHealth standards adoption was informed by four technology adoption theories, i.e. Diffusion of Innovation Theory (DOI), Unified Theory of Acceptance and Use of Technology (UTAUT), Internet Standards Adoption (ISA), and Success Model of Innovation Adoption. We argued that since standards adoption and implementation is an iterative process, then to attain success all phases of the standards adoption and implementation process must be involved. Thus the inclusion of pre-adoption, adoption, and post-adoption phases in the conceptual model. Furthermore, the study identified four major dimensions of success factors of standards adoption to include, including the adoption process, the user, organizational, and community contexts. Finally, the study identified thirteen factors that influence the success of eHealth standards adoption. However, these factors may not in the current form be useful to assess potential success and therefore need to be evaluated/validated. Future research should focus on validating the potential success factors to determine their impact on the adoption of standards for eHealth in Uganda's health system.

Acknowledgements

As PhD students of Makerere University, the authors would like to thank their respective workplace institutions for the support offered towards our studies. In addition, we would like to thank our study supervisors for their guidance and mentorship.

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Journal of Health Informatics in Africa

Towards a Digital Health Curriculum for Health Workforce for the African Region: A Scoping Review

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Background: Digital technologies are fast gaining space in health. A skilled workforce is required to use existing and emerging technologies that support healthcare. However, existing medical informatics curriculum from the USA, UK, and African regions reveal gaps in the required competencies for a digital health worker, especially for the African region. Therefore, this study aimed to identify the need for and suggest a structure of the digital health curriculum for the African region.
Methods: The study retrieved articles published in English between 2000 and 2019 from PubMed Central, Google Scholar, and Biomedical Central. Only 39 that addressed any form of pre-service and or in-service training of the digital health workers were included in the review. Also, eight national eHealth strategies and 13 medical informatics curricula from the USA, UK, and African regions were reviewed to determine the gaps and suggest a structure of the digital health curriculum suitable for the African region.
Results: Many countries in the African region have developed eHealth strategies that highlight the need to train the digital health workforce. Results showed the knowledge gaps of a communicator, a collaborator, a professional technologist, an advocate, and a manager required of digital health workers in the African region. However, the existing digital/health informatics programmes in the region lack balanced course programmes to develop these core competencies. Besides, the corresponding online training is modeled after the traditional face-to-face training, thus limiting the opportunity for in-service health workers. Validation of the Lesotho curriculum confirmed only 10 modules are suitable to develop a rounded digital health worker (particularly health leaders) for the African region.
Conclusions: Since it is important to develop the competencies consistent with the local health systems to realize the full benefits of eHealth technologies, the African region needs to bridge their human resource gaps. Thus, African countries need to first develop or adopt a digital health worker competency framework and then re-organize their national health training curriculum to ensure a standardized/universal eHealth curriculum for training the digital health workforce. Future works will assess the digital health worker competencies and expected outcomes for the African region.

Keywords: Competence, Curriculum, Digital Health, eHealth, Health Worker, In-Service, Training

1 Background

Digital health (DH) is considered to be an umbrella term encompassing eHealth and mHealth, as well as emerging and developing computing areas such as artificial intelligence and the internet of things that support healthcare [1] [2]. Whereas *technology* has also been defined as "… any product that can be used to create, view, distribute, modify, store, retrieve, transmit and receive information electronically in a digital form" [3], *Digital Health Technologies* (DHT) widely refer to eHealth technologies that present new or improved ways of delivering healthcare, conducting health promotion activities and monitoring public health [2] [4]. The technologies are geared toward meeting the growing demand for healthcare [4] [5]. The human resources required to design, deploy, manage and/or use these technologies in support of healthcare need to be properly trained [6]. Of particular interest to this study are health workforce skills, which include skills, experience, and knowledge to apply eHealth in the management and delivery of care to individuals and support of eHealth services [7]. Thus, a diverse workforce herein referred to as *Digital Health Worker (DHW),* needs to be engaged holistically to develop, operate and support the national eHealth environment [7]. This workforce can be drawn from multiple professional backgrounds and diverse service providers [5] such as clinicians, health informatics professionals, IT professionals and professional managers [8]. Although Ahonen *et al* [9] pointed to the need for a multi-

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professional curriculum and a combination of trainable competencies for quality DH and welfare service development, these competencies are greatly lacking not only in the African region but across the world [10]. To date medical training institutions, have not integrated core courses that develop competencies of professional to use DHTs for patient care in their academic curricular [11]. Therefore, graduates from these medical training institutions have continued to lack the multi-professional requirement for a health worker to possess requisite skills to use digital technology to support healthcare. Consequently, Barakat *et al* [5], argue for education and training of healthcare professionals in the latest tools and methods to accelerate acceptance and use of digital technologies to collect, use and share information to support healthcare delivery. Besides, health workers need to be retrained to use emerging DHTs as they continue to evolve. .

Users may engage in using different DHTs that require different competencies or may use the same technology with broad functionality but still require different levels of competencies. The World Health Organisation (WHO) suggests that training and education programmes will need to ensure that the workforce can use digital technologies proficiently in many settings, whether in the delivery of care (*operational level*), its management and administration (*tactical level*), or in health systems planning and management (*strategic level*) [4]. However, most of the health workforce, especially in the African region, lack core competencies that are required to use digital technologies. Thus, the benefits of DH are not fully realised. Furthermore, attaining a competent workforce is strained by limited or lack of capacity to develop and sustain such a workforce. The curriculum can be tailored to train pre-service or in-service health workers. Furthermore, training modules and online courses are suggested for DHWs who may be remote from training institutions [4].

According to Lynott *et al* [12], the current health systems' training is not standardized and lacks the content that may be required to address the DHW needs. As such, a curriculum is required to guide the required training of health workers to equip them with the required competencies to implement, operate and use eHealth technologies [13]. For example, such training modules should incorporate the universal eHealth components, like electronic health records [12] with an aim to strengthen the training of health workers. This will increase the number of healthcare professionals with DH competencies to support improved healthcare and quality service delivery [14]. Given this background, this paper aimed to identify the need for, and suggested a structure for the DH curriculum for the African region, through exploring; *what DH training needs existed for the African region*, and *what structure of the DH curriculum could guide the pre-service and in-service training of the DHWs across the African region*.

The rest of this paper is organised as follows: Section 2 discusses the state of DH workforce and a conceptualization of required DH training in the African region. Section 3 presents the scoping review methodology that was followed in this study. Section 4 presents results for the proposed DHW training curriculum for the African region and assessment of required competencies in selected training programmes across the world. In Section 5 is a discussion of the required DHW competencies leading to a structure of the DHW training curriculum (both pre-service and in-service training curricular) suitable for the African region. Finally, the conclusion and possible future works are presented in Section 6.

2 State of DH Workforce and Conceptualization of Training Competencies in the African Region

2.1 The African Region DH Situation

Besides the shortage of trained healthcare professionals working in Africa, less than 50% of Africans have access to good health facilities [15]. This situation can be improved by DHTs and several innovations continue to be developed to bridge the gaps. However, these innovations are not matched to the requisite health worker usage skills [6]. According to Steen and Mao [8], there is a lack of skills among the health workers for mHealth, eHealth, telehealth, health information technology, and telemedicine applications as well as wearable technologies, big data and use of artificial intelligence in healthcare. The lack is also experienced in the design, deployment, and management of DH systems [6]. Several eHealth strategies for countries in the African region identified the lack of skilled DH workforce among the challenges to their eHealth strategic objectives [13] [16] [17] [18] [19] [20] [21] [22]. One way to bridge the gaps is by way of appropriate training of DHs [14].

Actually, countries across the African region are at different stages of implementation of the Digital systems. These countries have identified the need to train a DH workforce as one of the key components of their DH programs [16] [17] [18] [19] [20] [21] [22]. The last survey on eHealth conducted in 2015/2016 in the region, showed that 18 out of 33 countries were offering pre-service training in eHealth, while 19 out of 33 countries were implementing eHealth capacity building for in-service health professionals [23]. From this survey, it is clear that countries in the African region lack trained health workers with the capacity to design, deploy and manage eHealth

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projects and programmes [6] [7]. The lack of well-trained ICT professionals, insufficient awareness and experience in the use of ICTs remain important challenges to eHealth success in a developing country [6] [24]. The problem is aggravated by limited opportunities for education in eHealth with most courses available only at the post-graduate level [18]. For example, Uganda's eHealth strategy expresses this as a deficit of adequate health informatics skills that need to be addressed [19]. Generally, the African region lacks a standard DH curriculum to guide the training of the health workforce in the region; this poses a risk for fragmented and uncoordinated DH skills workforce development. Workforce training are activities planned to make DH knowledge and skills available through internal expertise, technical cooperation, or the private sector [25]. It includes establishing eHealth education and training programs for the DH capacity building.

Largely, the above problem can be addressed through a mix of continuing education programmes like in-service training and pre-service training courses embedded in the main training curriculum as previously recommended [6] [26]. Specialized eHealth technology training, short eHealth training programmes or online courses should be provided as part of the continuing education for health workers; relevant ICT courses can be introduced in the curricula of all healthcare training institutions [6] [26]. To address the lack of ICT skills among the DH workforce, ITU's report on ICT for health recommends that a basic start is the adaption of medical students' curricula to include more courses about the new advancements of ICTs and eHealth [27]. Moreover, one of the recommendations of the WHO World Health Assembly A71 resolution on DH relates to health workforce development and skills in DH, i.e. "t*o build, especially through digital means, capacity for human resources for digital health, as appropriate, across both health and technology sectors, and to communicate areas of specific need to the World Health Organization in order to receive appropriate technology assistance*" [28]. Ultimately, to address this gap, some countries in the region such as Kenya, Ghana, Rwanda, South Africa, Uganda and Zambia among others embarked on implementing this resolution through the development of eHealth strategies. For example, Uganda's eHealth strategy identified the need to '*develop and enforce an eHealth Curriculum Framework to be followed by different training providers in developing and delivering Health training*' [19]. A standardized structure for the DHW curriculum is expected to produce professionals who can adapt to the fast-changing eHealth technological environment and thus, can work across the board.

2.2 The BioMedical/Health Informatics Training Curriculum

In order to produce professionals with the required competencies to perform particular tasks, formal training institutions have used the model of a training curriculum. According to McNay [29], as summarised in [30], a *curriculum* can be considered to be a written plan of a degree programme, a syllabus, a course outline, a course study, a course guide, or a learning package. Thus, the *digital health curriculum* may be a dedicated bio medical/health informatics degree programme or syllabus [26], a course within medical professional pre-service training programme, a specialised eHealth technology study programme, a learning package for the in-service staff or an online eHealth technology training package which must be properly structured and documented. Whether they are in or outside the school, any planned training is considered part of a curriculum [31].

Types of Training in the Healthcare Profession.

In the healthcare profession, commonly used modes of health worker training include *pre-service training* and *continuing training* [32], which Asamoah-Odei, *et al* [6] further suggest for the systematic education for health workers in DH. *Pre-service training* is the formal training provided by the health institution to introduce core skills earlier to health workers during their formal training [33]. *Continuing training* embodies in-service training, refresher training, and or supportive supervision [34] [35]. *In-service training* or refresher training is training received by existing staff after their formal/initial professional training. The purpose of in-service is to acquaint employees with new skills, methods, procedures and or processes required to better their work performance [36]. Although in-service training is considered to be expensive requiring the trainees to leave their workplaces [33] [34], it is also considered to be very effective in healthcare cycles and has greatly facilitated the transfer to ICT-based work skills and routines among health professionals [37]. Supportive supervision is recommended for healthcare where supervisory visits provides better opportunities to improve work knowledge and skills [35]. Asamoah-Odei, *et al* [6] argue that such systematic education must be at the heart of any strategy designed to facilitate eHealth. In fact, the GEEKS and I-LEAD programmes from the Centres for Disease Control (CDC) have expressed need to develop or adopt diverse DH training programmes for the African region. They have suggested that learning exchange visits and continuing education are crucial for quality improvement in healthcare [38]. Therefore, to guide the proper (systematic and quality) training of DHWs for the African region, this study explored competencies that qualify the healthcare workers and discuss the need to impart similar competencies to a DHW.

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Healthcare Professional Competencies.

To identify the professional competencies required for digital health personnel/health worker, this study reviewed three key frameworks/models for training healthcare professionals, i.e., CanMEDs framework [39], education model for equipping health professionals (with a focus on in-service personnel) with mHealth skills [11], and the European Digital Competence Framework [3] [40].

A. The CanMEDS Framework

The CanMEDS framework [39] has been widely used across countries to guide training in the different branches of medical education including nursing education [5]. The framework stipulates six integrated sets of roles to qualify as a medical expert, i.e., a communicator, collaborator, manager, health advocate, scholar and professional (see Table 1). In training a DHW, we argue that since they provide services that support healthcare, their learning outcomes should be aligned to most of the roles of a medical expert in the CanMEDS framework. Besides, the use of DHTs does not exempt healthcare workers and professionals at all the levels (strategic, tactical, and operational) of the healthcare system from utilizing the competencies developed by the CanMEDS framework. If properly used, the technologies aid their skills in communication, collaboration, decision-making, clinical competence, and health promotion among others, to advance care and wellbeing for all.

Table 1: Competencies of a Healthcare Professional as adapted from CanMEDS framework [39]

Roles	Brief Description	Competencies
Communicator	• Communicator and a facilitator of the dynamic doctor-patient relationship (before, during & after the medical encounter)	• Communication skills to establish rapport & trust • Facilitation skills for shared decision-making & plan of care
Collaborator	• Working in partnership with others involved in the care of an individual/group	• Effective collaboration skills • Domain knowledge/expertise
Manager	• Active engagement of all physicians as integral participants in healthcare decision-making	• Planning & strategic thinking e.g. in resource allocation • Problem-solving & Decision-making
Health Advocate	• Use of activities to advance the health and well-being of patients, communities, and populations	• Health promotion • Policy formulation
Scholar	• A lifelong commitment to reflective learning, as well as the creation, dissemination, application, and translation of medical knowledge	• Create, disseminate, apply and translate medical knowledge, • Facilitate the education of their students, patients, colleagues, and others.
Professional	• Dedication to health care of others • Mastery of a complex body of knowledge and skills, as well as the art of medicine	• Clinical competence • Code of ethics - appropriate attitudes and behaviors, integrity, altruism, personal well-being, and to the promotion of the public good within their domain

B. Education Model for Equipping Health Professionals with mHealth Skills

Slovensky *et al* [11] proposed a model for preparing health professionals (with professional clinical knowledge and skills) in the deployment and use of mHealth interventions. Their model presents five key knowledge areas in the preparation of a health professional to use biomedical and communication technologies including digital communication skills, technology literacy, and usage skills, deploying telehealth products and services, regulatory and compliance issues, and telehealth business case (see Figure 1). Also, they highlight the need to address organizational issues especially as part of in-service training and collaborations. The organizational context in the African region consists of the country's health system including both the public and private healthcare institutions. Membership to the DH workforce drawn from different professional backgrounds, with varying skills, requiring tailor-made induction or in-service training to prepare them for optimal use of the DHTs at work.

Thus, in their model for preparing health professionals (with clinical knowledge and associated technical skills) to deploy mHealth, Slovensky *et al* [11] identified the following as required core competencies for a DHW;

- Digital communication skills are provided to acquaint the health worker in the use of various digital communication technologies in a rapidly changing communication environment. Unlike basic communication skills that can be outlined in a simple document, digital communication is a behavioral

skill best learned through the application, feedback, and practice [11] and impacts the encounter in an examination room [12].

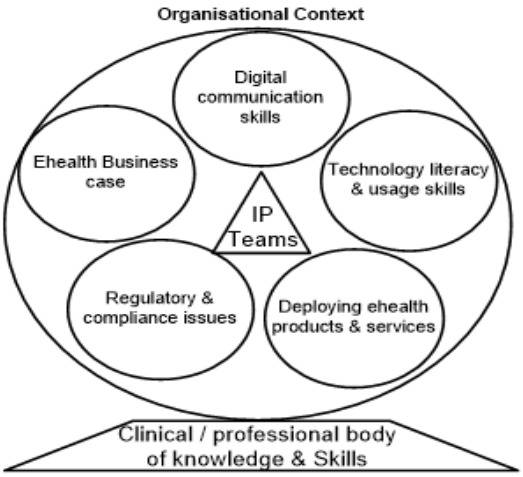

Figure 1: Education Model for Equipping Health Professionals with m(e)Health Skills adopted from Slovensky et al [11]

- Technology literacy and usage skills are required for the DHW to use digital technologies and more so, know when to use technology to support healthcare. Rather than the technologies replacing human function in healthcare, it should complement humans such as in-patient consultation.
- Deploying telehealth products and services requires a proper understanding of the technology in addition to using technology to manage multiple stakeholders, policies and organizational dynamics.
- The health workers must understand the regulatory and compliance issues since they work with personal information regulated by the legislation. The organizational context such as the African region's health systems should have patient health information sharing guidelines that the DHW needs to learn and follow in addition to any other technology compliance regulations.
- Understanding the telehealth business case is required for a DHW to appreciate both the clinical and business perspectives for better outcomes. A proper understanding of the business case can enable the DHW to recommend a viable case of DH intervention for the organization.

The model focuses on professionals with an assumed clinical/professional body of knowledge and skills but lacking some or all of the aforementioned body of knowledge/skills to deploy and use eHealth and mHealth. In this respect, we suggest applying this model due to its suitability regards defining the training skills-set for in-service healthcare professionals especially in the African region, where healthcare professionals lack the required eHealth competencies in addition to low levels of basic ICT skills.

C. The European Digital Competence Framework

The European digital competency framework [3] [40] highlights the major areas of any digital competence, which we associate with the needed competency for a DHW including;

- Competency in information and data literacy enables the DHW to identify, locate and retrieve the relevant health information in addition to storing and managing them in a digital format.
- Communication and collaboration competency enables the use of eHealth technologies to interact, exchange information, engaging in citizenship, and collaborate netiquette and managing the digital identity of clients.
- The handling of healthcare digital content includes creation and management. Data (clinical, referral, care, patient historical data among others) contributes a greater percentage to the digital content created in a healthcare environment. The need for big data analytics (mining) was previously predicted as important skills for the future (the present) informaticians [41]. Therefore, the present and future DHW needs skills in big data analytics including an understanding of how to make improvements and integrate information and content into an existing body of healthcare knowledge while following applicable copyright and licenses (authorization) procedures.
- A DHW with privacy and safety skills can appropriately enforce the protection of digital devices, personal data, and privacy measures. It also covers health protection and wellbeing in addition to protecting the environment.

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- Problem-solving competency allows the digital worker to identify digital technology needs and gaps and creatively use digital technologies to solve technical problems. The DHW needs to keep to-date with the digital evolution. In addition, competency in problem-solving includes improving/modifying existing solutions in new problem contexts, troubleshooting complex issues that require eHealth technological innovations or even troubleshooting and fixing problems in the technologies. Unlike the European context where expertise is readily available, in the African context, the responsibility to fix minor failures e.g., destination unreachable due to the unpowered access point in a facility setting may belong to the health worker.

Based on the above frameworks' DH competencies for the health workforce and Mantas *et al* [26] recommendation to developing countries to adapt the required knowledge, skills, and competencies with regard to the level of technology; we suggested to bridge such gaps in the skills for the DHW in the African region by integrating the competencies from the Education Model Equipping Health Professionals with mHealth Skills [11] and European digital competency framework [3] [40]. The integration of these competencies is to guide the training of the DH worker's branch of medical education as per the CanMEDs framework [39] as recommended by [5] (see Figure 2).

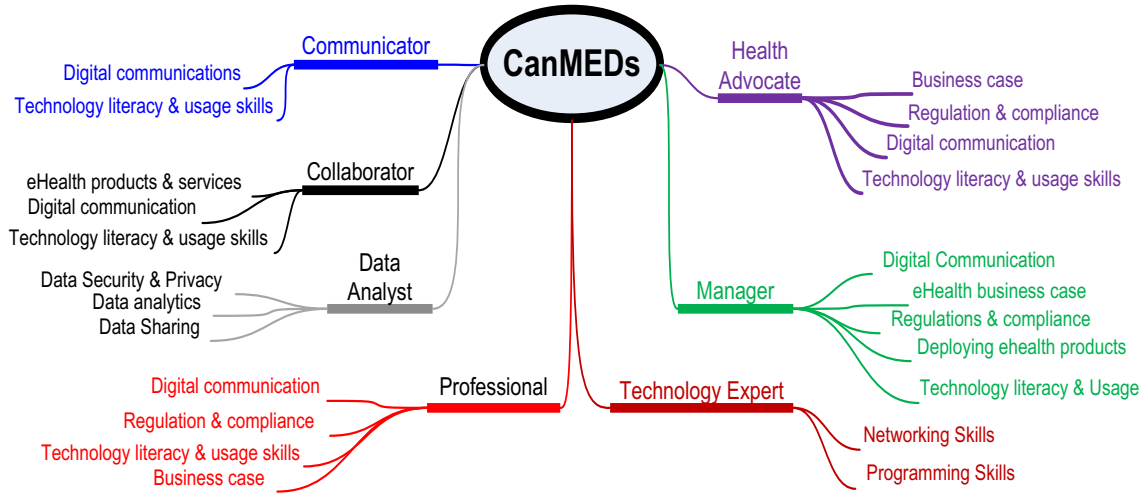

Figure 2: Proposed Learning Requirements for a DHW for the African Region

In this regard, we considered the competencies for a DHW and categorized them as in Figure 2, according to the roles of the CanMEDS framework for a health professional. We developed upon the three-domain areas of methods and technologies for healthcare data processing, medical sciences, and health system organization and informatics as recommended by the International Medical Informatics Association as highlighted in [41]. The expectations for a DHW include being a good communicator, a collaborator, a professional, an advocate and a manager; analyst of the big health data generated, protect the security and privacy of health data/information in their care and being able to fix minor failures in the technologies they use. It should be realized that the required levels of competencies might vary according to the expectations of the work position. Some of the training may only be basic/foundational, intermediary, advanced or even specialized / expert [40].

3 Methods

The study used both published and grey literature in the review, review of peer-reviewed literature, eHealth strategies and existing DH training curricula across the globe.

Searching: Peer-reviewed articles related to DH training and or curriculum were retrieved from PubMed Central, Google Scholar, and Biomedical Central. The databases were selected on the basis that most biomedical and health informatics publication is indexed in PubMed and Biomedical central. Any other publication on medical related training on use of digital technologies that is not indexed by these two can be retrieved via google scholar. The following search strings were used;

(a) PubMed Central: (((((digital[Title/Abstract] OR electronic[Title/Abstract]) OR computerized[Title/Abstract]) AND health[Title/Abstract]) OR healthcare[Title/Abstract]) AND curriculum[Title/Abstract]) OR syllabus[Title/Abstract] AND ("2000/01/01"[PDAT] : "2019/03/31"[PDAT];

(b) Biomedical Central: (((((((digital[Title/Abstract]) OR electronic[Title/Abstract]) OR computerized[Title/Abstract]) AND health[Title/Abstract]) OR healthcare[Title/Abstract]) AND curriculum[Title/Abstract]) OR "training program"[Title/Abstract]) OR "training programme"[Title/Abstract]) OR syllabus[Title/Abstract]; and
(c) Google Scholar: "digital health" AND "electronic health" AND curriculum OR "training program" OR "training programme" OR syllabus. The search returned 2502, 111, and 918 in PubMed central, Biomedical Central and Google scholar respectively.

For grey literature, we searched the websites of medical and or health informatics training institutions/organisations. Websites of the ministries of health in the African region were also searched for eHealth respective country's eHealth strategies.

Inclusion/exclusion criteria: Articles were included in the review if they addressed any type of health worker pre-service training or continuing education (in-service training) in the use of ICT or eHealth technologies (including mHealth, telemedicine, health information systems, among others) to support healthcare. We included only those articles published in English language literature between 2000 to 2018. This is because the term eHealth started to be used in literature around the year 2000 [42]. Articles that lacked consideration for DHW skills training and those that generally focused on medical worker training without attention to equipping them for the digital environment were excluded. Also included in the review were national eHealth strategies of six countries in the African region, and select health informatics training curriculum across the globe. The medical training institutions and ministries of health were purposively selected. The criteria for inclusion were; (1) the academic institution/organisation had pioneered training programmes on DH systems in their respective regions, (2) the training institution/organisation had researched for, promoted or partnered with government in the implementation of eHealth programs within their respective countries or states, (3) the country had developed eHealth strategy, and (4) the country was advocating for the implementation of eHealth systems in its healthcare practices.

Data extraction and synthesis: Two reviewers were involved in extracting data from the articles that were included in the review. Data extraction was guided by the learning requirements (competencies) for a DHW for the African region (Figure 2) that was developed from the CanMEDs framework, education model for equipping health professionals with mHealth skills, and the European Digital Competence Framework. Key features that were considered for the peer-reviewed articles were: author, year, type of study, themes regard DH training such as human resource needs, skills gaps, required competencies of a DHW, etc. Data from eHealth strategies included; author/ministry of health, country, document title, year, eHealth human resource gaps/challenges and recommendations. Then, data from selected training included the title of the DHW training programme, institution or organisation that was offering it, the study type (pre-service/in-service) and the number of courses that attempted to develop the core competencies expected of a DHW.

To identify the gaps that justified the need for a DH training curriculum for the African region, a meta-synthesis of the primary data was done. The data were synthesised by the themes regards the state of DH training, what the ministries of health in the African region said regards DHW needs and the existing human resource gaps/challenges in the African region. These themes guided the integration and interpretation of our study findings.

4 Results

In this review, only 63 documents were included in the reporting after the screening of originally identified 1,233 non-duplicate records that met the search criteria and applying the exclusion criteria as shown in Figure 3. The records included 39 peer review documents and reports on eHealth/DH human resource capacity needs, digital competency, and health worker training from WHO and regional governments like the European Union, East African community among others; 13 health/medical informatics training curriculum; and 08 national eHealth strategies.

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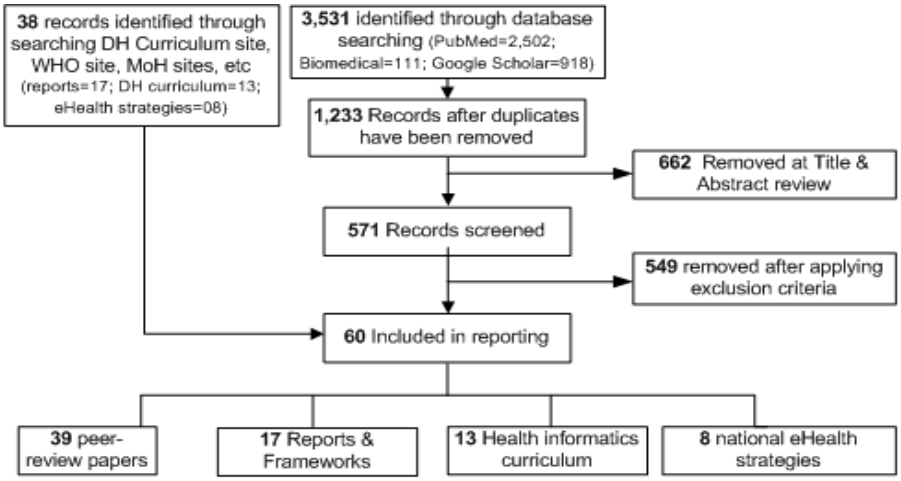

Figure 3: Flow-chart showing the search strategy and inclusion/exclusion criteria

Key features of the peer-reviewed records that were included in the review discussed components of the healthcare professional curriculum, expected competencies of a DHW, and the need to equip the health workers with digital skills. According to Hersh *et al* [43], it is important to identify and develop competencies consistent with the local health systems that are needed to realize the full benefits of eHealth technologies. Consequently, we first identified the need for a DH curriculum to guide the proposed structure for the African region.

4.1 Need for DH worker training curriculum for the African region

This was guided by reviewing the eHealth strategies for eight African countries. The choice of countries for review of eHealth strategies was based on their efforts towards national implementation of eHealth. Additionally, the assessment of the selected DHW training programmes across the globe was done. Results in Table 2 show the gaps in human resources required to use digital technologies as identified by individual countries. To note is that the review revealed similar, but broad knowledge gaps/challenges across the African continent (see Table 2).

Table 2: Human resource needs as identified by eHealth strategies of eight African countries [13] [16] [17] [18] [19] [20] [21] [22]

Author, (year) Title of document	Country	Identified eHealth knowledge gaps/challenges	Recommendations
Kenya Ministry of Health, (2017) Kenya National eHealth Policy 2016-2030	Kenya	–Expertise in eHealth applications –Skills needed to use and maintain eHealth systems –Technical knowledge to support other users of eHealth system	–Develop & incorporate a universal curriculum in IT training in health training institutions –Capacity building / online & change management training
Uganda Ministry of Health, (2016) Uganda National eHealth Strategy and Policies	Uganda	–Insufficient biomedical/medical informatics experts and trained ICT professionals –Inadequate integration of eHealth skills into existing health professional training curricula –Inadequate awareness of electronic information security and privacy measures	–Conduct DHW training and skills need assessment –Develop, adopt or adapt eHealth skills and competencies framework –Develop & enforce eHealth Curriculum Framework –Conduct Personal Information Privacy training and awareness
Ghana Ministry of Health, (2010) Ghana National eHealth Strategy	Ghana	–Low levels of computer literacy / low adaptation to current ICT trend –Very limited exposure to ICT during training –Lack of professional training in the management of eHealth –ICT capacity building is directed to use training in the use of applications, not technical skills	–Include basic practical ICT skills in systems that support e-health –Define a standardized e-health competency framework for health workers and health sector information technology practitioners –Embed e-health into their continuing education curricula –Grant access to electronic course materials and to indexed health literature

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Malawi Ministry of Health, (2014) The Malawi National eHealth Strategy	Malawi	–Lack of professional competency in eHealth –Lack of accredited educational programme and or training courses in eHealth –Lack of in-country tailored online educational or training programme, especially for in-service personnel	–Define a standardized eHealth competency framework for health workers –Determine the education and training courses suitable for the development of eHealth workforce capabilities –Establish a national qualification in health informatics for formal training and embed eHealth into the training curricula of post-secondary educational institutions –Collaboration with training institutions to develop, implement and deliver online training in eHealth
Nigeria Ministry of Health, (2016) National Health ICT Strategic Framework 2015-2020	Nigeria	–Inadequate workforce to develop, use and maintain Health ICT –Lack of method for accreditation/revision of health ICT training curriculum –Lack of clear career paths for Health ICT professionals	–Empower the workforce to develop, use and maintain Health ICT –Develop incentive mechanisms to encourage workforce development of Health ICT skills –Establish a methodology for accreditation and revision of Health ICT training Curriculum –Establish special Health ICT education, training and career paths
South Africa Ministry of Health, (2012) Natonal eHealth Strategy, South Africa 2012/13-2016/17	South Africa	–No standardized eHealth competency framework for health workers and health IT practitioners –Limited or no workforce to innovate, develop, deploy, maintain and support all eHealth interventions	–Establish a standardized competency framework for DHWs –Train more professionals to innovate, develop deploy, maintain and support all eHealth interventions
Tanzania Ministy of Health, (2013) Tanzania National eHealth Strategy 2012 – 2018	Tanzania	–Limited basic ICT training for health workers –Lack of eHealth training curriculum –Lack of online learning platform / digital materials that support eHealth education	–Develop and approve a methodology for delivering blended learning, including basic ICT training for health workers. –Develop an eHealth education or training curriculum/program for various health workers. –Implement the health sector e-learning platform. –Develop digital resources to enable offline learning for areas with limited Internet access along with online learning.
Zambia Ministry of Health, (2017) eHealth Strategy 2017 - 2021	Zambia	–Lack of ICT skills in healthcare training programmes –Low levels of eHealth practitioners	–Include ICT in the pre-service training curriculum, in-service, task shifting of ICT tasks –Integration of all existing eHealth curricula for modular and cadre-based training, e.g., implement changes to vocational and tertiary training programs for the increasing number of eHealth practitioners

4.2 Overview of DHW training programmes: assessment of required competencies

In recognition of the need for healthcare professionals to be digitally competent, the European countries have taken steps to provide the required training/learning in the use of eHealth technologies to health workers [10] [40]. A review of how some of the existing DH curriculum/training programmes in the USA, UK, and African countries were geared towards developing the core DH competencies is summarised in Table 3.

Table 3: Course distribution for DHW competencies in 14 health informatics training programmes/curricular from the USA, Europe, and African regions

DHW Training Programme	Where / Institution	Type (pre-service/in-service)	# of courses developing the competencies										
			A	B	C	D	E	F	G	H	I	J	K
Digital Health Systems	University of Strathclyde, Glasgow[1]	Pre-service	0	0	1	0	1	0	2	0	2	1	1

[1] https://www.strath.ac.uk/courses/postgraduatetaught/digitalhealthsystems/

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Health Informatics		The University of Sheffield[2]	Pre-service	0	0	2	0	0	1	0	0	2	1	1
Health Informatics		University College London[3]	Pre-service	1	1	2	1	1	0	1	1	1	1	2
Master in Interdisciplinary Data Science		Duke Center for Health Informatics[4]	Pre-service	0	1	0	0	0	0	2	0	4	0	3
Electronic Health Records Management		Ashworth College[5]	Pre-and In-service	0	1	2	3	2	1	0	0	1	3	0
BSc in Health Information Management		East Carolina University[6]	Pre-service	1	0	3	3	4	3	1	1	2	6	3
Biomedical and Health Informatics	Clinical Health Informatics	The University of North Carolina at Chapel Hill[7]	Pre-service	0	1	4	0	1	5	6	0	8	2	1
	Public Health Informatics		Pre-service	0	1	2	2	1	5	5	0	5	0	1
MSc. in Applied Health Sciences Informatics		Johns Hopkins School of Medicine, Division of Health Sciences Informatics[8]	Pre-service	2	0	2	5	1	3	1	1	2	4	16
MEASURE Evaluation		MEASURE Evaluation[9]	In-service	0	0	2	1	0	0	0	1	1	1	0
Medical Informatics		University of KWAZULU-NATAL[10]	Pre-service	1	0	0	3	2	2	1	0	2	1	0
Masters in Health Informatics		University of Ghana[11]	Pre-service	1	0	2	1	1	0	5	1	8	3	2
Masters in Health Informatics	*Public HI*	Makerere University[12]	Pre-service	1	0	1	1	1	3	2	2	2	5	2
	HI major		Pre-service	1	0	1	1	1	3	0	0	3	7	2
MSc. Health Informatics		University of DAR ES SALAAM[13]	Pre-service	4	0	0	1	2	2	3	2	4	3	3

Notes: Assessment of course distribution per competency/knowledge area in existence in some of the existing DHW curriculum/training programmes across the USA, UK, and the African region. A = Technology literacy & usage skills; B = Digital communication; C = Deploying eHealth; D = Products & services; E = Regulation & compliance (implementation); F = eHealth business case; G = Configuration & Programming; H = Security and privacy; I = Data Handling; J = Healthcare introduction & terminologies; and K = Practicum & Research Methods.

This assessment shows the gaps in existing training curricula across the globe including the limitations in tailor-made courses and their improper distribution to develop balanced DHW competencies, they remain largely modelled after the traditional face-to-face limiting opportunity for continual education, and lack of or limitation in courses that provide training in the use of eHealth technologies among others. Most of the existing curricula are tailored to provide only pre-service training, with very few presenting options for in-service training of healthcare professionals.

5 Discussion

Following from the results presented in Table 1, the countries are representative of advancement in eHealth among the Anglophone countries. They have developed eHealth strategies that highlight the need to train the DH workforce. To bridge these human resource gaps, the African countries need to first develop a DHW competency framework and then re-organize their national health training curriculum to ensure a standardized/universal eHealth curriculum. Thereafter, the DHW can acquire the necessary skills and knowledge in the areas of basic IT, eHealth technology use, technical support and security measures needed to optimize the use of eHealth technologies. To achieve the objectives of technology to deliver healthcare, the interest may be on "*how to use"*

[2] https://www.sheffield.ac.uk/postgraduate/taught/courses/

[3] https://www.ucl.ac.uk/health-informatics/study/postgraduate-taught-programmes/health-informatics-msc

[4] https://datascience.duke.edu/mids-courses

[5] https://www.ashworthcollege.edu/career-diplomas/electronic-health-records-management/curriculum/

[6] http://www.ecu.edu/cs-dhs/hsim/bs_him/index.cfm

[7] https://chip.unc.edu/mps-bmhi-curriculum/

[8] https://www.hopkinsmedicine.org/som/students/graduate-programs/welcome/programs.html

[9] https://www.measureevaluation.org/resources/health-informatics-for-low-and-middle-income-countries-short-course-for-health-information-system-professionals

[10] http://is.ukzn.ac.za/Courses/medicalinformatics.aspx

[11] http://www.ug.edu.gh/biostats/courses?field_department_tid=5

[12] http://www.musph.ac.ug/index.php/accordion-2/152-mhi

[13] http://cse.udsm.ac.tz/index.php/programmes/postgraduate/msc-health-informatics

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ICT to deliver better healthcare; to conduct health promotion, there may need to understand "*ways in which"* ICT can be used as a leverage to promote health; and to monitor health, the focus may be on "*ways to use"* eHealth technologies as a media to monitor public health.

In order to attain the understanding of *how to use, ways in which* and *ways to use*, different authors have identified competencies that the different professions may bring to the DH (i.e., eHealth, mHealth, telehealth, electronic records, etc.) and maybe instilled in the DHW including but not limited to; basic IT literacy, communication skills, healthcare physician, management and development, IT guidance/support, range of DH technologies, information privacy, and confidentiality, biomedical/health informatics, among others [5] [9] [44]. These competencies align with those required of a DHW in Figure 2. For example, in a Delphi-study of competencies required for nursing telehealth activities, Van Houwelingen *et al* [45] identified knowledge, attitudes, general analytical and privacy skills, technological skills, clinical skills, communication skills, and implementation skills. These competencies cut across nursing professional work and those required for the use of digital technology to support nursing function, enhancing their ability to combine nursing experience into DH.

Regards the assessment of the existing DH curriculum, a study by Nishimwe *et al* [46] of health informatics competencies in undergraduate programmes at the University of Rwanda, identified only ICT literacy and use skills, informatics terminology and digital communication as the most present. However, regards the training of a DHW for the African region, the results in Table 3 reveal the following common themes/gaps do exist in producing a communicator, a collaborator, a professional technologist, an advocate, and a manager;

(i). Short training courses are tailored to develop crucial/urgent competencies for a target group. Example of the Farr Institute[14] besides technical training, embedded professional skills such as communication, leadership, influencing ability and decision making into its training courses.

(ii). Most programmes lack courses to develop the core competencies required for a DHW, e.g., technology literacy and use, digital communications, security, and privacy. Although configuration and programming had a large number of courses, they do not focus on issues critical to the successful implementation of DH in Africa; issues such as establishing communication medium for uploading digital data, setting up security measures inbuilt in the digital technologies, etc. Hence, courses should be tailored to develop these competencies, which are desirable for the African region.

(iii). Although some of the programmes are online/distance-learning programmes, most of those in the African region is modeled after the traditional face-to-face training; limiting the opportunity for in-service health worker from becoming a DHW. It may be beneficial to introduce online or distance learning programmes to cater to these groups of workers in addition to supporting the introduction of new technology or boosting refresher training programmes. In-service training is considered very effective and can greatly facilitate the transfer to ICT-based work skills and routines among health professionals [37]. The mode of delivery affects the worker's desire to engage in training. Besides, the workers in the healthcare sector are faced with personnel shortage; hence their high workload limits the time required to engage in continuing education.

(iv). Limited or non-existent courses to provide specialized training in the deployment and / or use of eHealth technologies. The curriculum needs to provide for various specialized training in existing and emerging eHealth technologies such as DHIS2, EHR, EMR, PHR, and MHealth applications. For example, in Uganda, a single medical records officer may have to work with a wide range of systems like EHR, DHIS2, etc., in addition to providing technical support, use of HR systems, connecting and reconfiguring the facility WIFI, etc.

(v). Although data handling has more courses, the reviewed programmes excluded content on blockchain technology, which is one of the emerging technologies that ensure the integrity of digital data content. Furthermore, existing courses focus largely on data analytics than security and privacy, which is quite essential to health data. Security and privacy courses are completely missing in most of the programmes.

(vi). The existing training programmes/curricula lack a common structure for preparing DHWs. While some had more courses, others had less for a particular digital competency area implying products from different training institutions/programmes may possess varying levels of proficiency. There is, therefore, an urgent need to develop a standardized DHW curriculum or re-structuring the existing curricula to produce comprehensively skilled DHWs for the African region. Equipping of DHWs across the board with similar skills will enhance cross-border eHealth information exchange to consult and healthcare management.

(vii). The concentration of programmes and/or courses on developing particular competencies with little to no regard for other core competencies as exemplified by most of the academic training curricula. Thus, regardless of whether it is the University College London programmes in health informatics, health data science, and health data analytics or the Makerere University health informatics programme, they all focus

[14] http://farrinstitute.org/research-education/education

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on developing limited DHW competencies. This may be wanting for the African region where the need is for a broad set of competencies.

Ultimately, given the gaps above observed in the various countries' eHealth strategies and the assessment of the digital worker training programmes across the globe, this created an urgent need regards developing a standard DH curriculum that can be used to train DHWs in the African region. In this regard, the study designed a structure for a standard DH worker-training curriculum for the African region.

5.1 Design Structure of the Standard DH Worker Curriculum for the African Region

The Digital Health (DH) curriculum for the African region should produce workers that satisfy personnel needs of the priority areas for eHealth highlighted in many of the African countries' eHealth strategies. However, the African region is characterized by multiple but distributed implementations of eHealth/digital technologies, thus require DHWs with diverse competencies to use them.

This study's assessment of the existing curricula across the globe helped to establish the DH curriculum trends, and thus determined what is suitable or what can be contextualised/customised for the African region with further adoption. In Table 4 and Table 5 respectively, are summaries for design structures of the standard DH pre-service and in-service curricula for the African region. Although studies have suggested that DHW training is incorporated into the standardized medical training curriculum [5] [10] [47], others advocated for training at the workplace (i.e. in-service training) [10]. Both approaches provide a suitable training environment for pre-service trainees and in-service professionals respectively. However, some consider in-service training to be very effective [37].

Whereas the in-service training curriculum in Table 5 is aimed to prepare in-service health workforce such as DH leaders in their work practices; the Pre-service training curriculum in Table 4 is based on a benchmark of the different types of DH worker curricula competencies across the globe, the DH worker needs of the African region and core competencies required of any DHW. In fact, there are calls to fill the knowledge and skills gaps for health workers using ICT to support healthcare [13] [16] [17] [18] [19] [20] [21] [22]. The competency framework is derived from the CanMEDS framework [39], the education model for equipping health professionals with mHealth skills [11], and the European digital competency framework 2.0 [3] [40]. Table 4 presents a summary of the proposed knowledge areas and competencies by levels of proficiencies that a DH Worker curriculum for the Africa region should have.

Regards the in-service training curriculum, it is guided by the recommendation of the Nigeria eHealth strategy that suggests the need for a nationally scaled health and ICT workforce education/training in addition to incorporating Health ICT into standardized curricula [17]. Table 5 presents a summary of the in-service (e.g. health leaders) training curriculum for the African region. It is based on the DH leadership curriculum that was designed, executed and validated in Lesotho in 2018, and assumes that the health leaders at the strategic and tactical levels of the healthcare system require knowledge/skills in the use of digital technologies to support their strategic and tactical decision-making. In this curriculum, the ten modules as shown in Table 5 aim to prepare the DH leader to understand the concept of DH and how it can influence the development of national strategies; identify DH interventions and requirements; design DH platform and applications; develop, deploy, maintain and scale-up of DH; use and analyse health data; and finally, how to monitor and evaluate DH systems.

The first three modules, i.e. 1-3 provide the underlying principles/foundations to understanding the concept of DH and how it influences the national strategy development. The three modules do introduce the DH systems and services and their key components that include strategy, governance, and regulations. To better understand the concept of DH, Maternal and Child Health (MNCH) and Non-Communicable Diseases (NCDs) are used as examples to explain and demonstrate how DH can be applied in the health system.

Modules 4, 7 and 8 provide *an overview of DH platforms and application designs*. Particularly module 4 summarizes the Global Goods and their applications including OpenMRS/Open Clinic, iHRIS, OpenLMIS, RapidPro, OpenSRP, Open Deliver, and Telemedicine among others. Global Goods are DH applications that can be used in various countries across the globe irrespective of health system settings. Module 7 specifically describes the DH architecture design including the business architecture, data architecture, applications architecture and digital platform infostructure, for which the OpenHIE is used as an example of health information architecture. Module 8 lays out the interoperability frameworks and highlights the standards and profile stacks for developing interoperability frameworks in varying health systems in the African region.

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Module 8 lays out the interoperability frameworks and highlights the standards and profile stacks for developing interoperability frameworks in varying health systems in the African region.

Module 5 then *introduces the development, deployment, maintenance, and scale-up of DH applications*. This module explains how to implement DH applications and infrastructure, and how to ensure its sustainability. It further explains the relationships between partnership models such as the health and IT industry e.g. the telecommunications and how they can support DH in the health sector.

Module 6 provides a *summary of DH intervention identification, requirements analysis, and deployment standards*. The module particularly describes the requirements gathering, technology inventory, Request for Proposal (RFP) development and determining ICT functionalities to address needs, prioritizing DH interventions viz-a-viz costing, project management & planning, stakeholder engagement, and human-centered design.

Module 9 explains the *monitoring, learning and evaluation components of DH systems*. The module entails an understanding of how to assess and continuously improve the maturity of Health Information Systems (HIS) to achieve better health outcomes. It further explains why and how Monitoring & Evaluation (M&E) is done, when and how to use global toolkits, continuous improvements in M&E including standards for assessing and monitoring implementation.

Module 10 deals with *data use and analytics*. This included how to use data and basic regulations governing data access and use. It also discusses related issues such as techniques for information needs assessment, principles of data harvesting and data visualization and information communication and a broad summary of data-related regulations and policies among others.

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Table 4: Digital Health Worker Competencies for the African Region: Pre-service Training Curriculum

Levels of proficiency	Level 1 – Basic	Level 2 – Intermediate	Level 3 – Advanced	Level 4 – Expert
Brief description	This is foundational & develops the DHW's literacy level. Provides common knowledge or understanding of basic eHealth technology techniques and concepts e.g., types of technology, purpose, how to use, etc. Key terms include use, find, identify, etc.	Training at this level aims at developing the DH worker's capability to independently use eHealth technology to complete tasks and to apply eHealth technology knowledge or skill in different situations. Key terms include explain, describe, illustrate, among others.	Advanced training equips the DH worker with techniques to apply the theory. Can perform eHealth technology tasks without help, it's a level of eHealth technology professionalism. Key terms include apply, show, propose, explain, vary, assess, etc.	This level prepares a DHW to provide guidance on specific eHealth technology(ies), troubleshoot and answer questions related to them or an area of expertise within the technology. The DHW becomes the consultant – "go to person" Key terms include create, integrate, propose, etc.
Expected Outcomes	– Understand and can identify medical informatics / eHealth terminologies, concepts, principles, and issues – Can utilize a full range of eHealth technologies	– Occasionally apply knowledge to different cases with minimal guidance – Understand and can discuss the application and implications of eHealth technology changes to processes, policies, and procedures – Chooses appropriate tools for tasks – Experiments with new processes, tools, or technologies to determine the applicability	–Provide practical/relevant ideas and perspectives on eHealth technology processes or practice improvements to be implemented –Coach others in the application of eHealth technologies translating complex problems to solvable forms –Support the eHealth technology development process plus references & resource materials	– Demonstrate consistent excellence in applying eHealth technology expertise across multiple projects and/or health systems – Create new technologies/application scenarios – Explain the relevant eHealth technology process elements and issues in relation to organizational issues and trends in sufficient detail
Possible competencies	– Can use computers & other ICTs – Can identify appropriate eHealth technologies – Browse, search, filter data, information, and digital content – Distinguish data, information and digital content – Can understand eHealth & medical terminologies; diseases codes, etc. – Can use inbuilt security measures	In addition to level 1 competencies, can; – Evaluating data, information and digital content – Managing data, information and digital content – Interact through digital technologies – Share through digital technologies – Engage in citizenship through digital technologies – Collaborate through digital technologies – Netiquette – Managing digital identity	In addition to level 2 competencies, level 3 DHW can; – Develop eHealth content – Integrate and re-elaborate on the eHealth digital content – Solve technical but eHealth related problems – Shares expertise, teaching skills and explaining concepts to others – Copyright and licenses	In addition to level 3 competencies, level 4 DHW can; – Improve or redesign eHealth processes, tools or technology – Implement and troubleshoot complex issues on eHealth technology(ies) of their expertise – Programming
Possible competency categories	– Technology literacy & usage skills – Literacy in medical & eHealth terminologies – Information & data Literacy – Security & privacy Literacy	In addition to level 1 competency categories are; – Digital communication – eHealth products & services	In addition to level 2 categorization; – Regulation & compliance (implementation) – Business processes	In addition to level 3 categorization; – Networking and Programming – Data analytics

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Example of security & Privacy application	**S E C U R I T Y a n d P R I V A C Y** **(Required at all levels of competency to protect devices, personal data, health & wellbeing and environment)**			
	Protect devices, use security measures on devices & inside applications, etc;	Protect devices, use security measures on devices, inside applications, on data/information sharing, etc	Protect & guide others on how to protect devices, applications, data/information privacy, etc	Improve or develop systems to enforce security & privacy

Table 5: Digital Health Worker Competencies for the African Region: In-service (e.g. Health Leaders) Training Curriculum

Integrated DH Building steps	Understanding DH	National Strategy Development	DH Interventions identification and Requirements Analysis	DH Platform and Applications Design	Development, Deployment, Maintenance and Scale Up	Data Use & Analytics	Monitoring & Evaluation
Training Modules	**Module 1: Introduction to DH** – DH Systems and Service – Health System Building Blocks – DH Solution – Value of DH & Transformative Role of DH	**Module 2: DH Strategy, Governance & Regulations** – Develop a national DH strategy outlining overarching needs, desired activities, and outcomes – Formulate a DH investment plan to support the national strategy – Establishing a governance mechanism	**Module 6: Implementing DH** – Requirements Gatherin – Technology Invento – Determining ICT functionalities to address needs: Prioritizing DH Intervention – Costing – Project Management & Planning – Stakeholder Engagement – Human Centered Design	**Module 4: DH Global Goods Applications** – OpenMRS/OpenClinic, iHRIS, OpenLMIS, RapidPro, OpenSRP, Open Deliver, Telemedicine, OpenELIS, openIMIS **Module 7: DH Architecture Design** – Business Architecture – Information Architecture – Digital Platform infostructure – OpenHIE as an example of a health information architecture	**Module 5: Partnership models** – Partnership models with telcos	**Module 10: Data use and Analytics** – Techniques for information needs assessment – Principles of data harvesting – Data Visualization & Information Communication – Data related Regulation	**Module 9: Monitoring, Learning and Evaluation** – Why and how-M&E – Global toolkits-When and how to use? – Continuous improvement – Adapt and accomplish – Assessing and monitoring the implementation
	Module 3: Examples of the use of DH – MNCH, NCD			**Module 8: Interoperability Framework** – What is interoperability – Standards & profile stacks – Developing the Interop. Framework	**Module 6: Implementing DH** – DH Deployment – RFP development		

 J Health Inform Afr. 2020;7(1):38-54. DOI: 10.12856/JHIA-2020-v7-i1-265

6 Conclusion

In this work, we reviewed the current state of the DHW curriculum across the globe with the aim to design a standard DH training curriculum for the African region. The study assessed various DH worker-training curricula across the globe to identify the DHW learning needs and the required competencies for the African region. The review showed limited core competencies and a lack of common curriculum structure across the existing DHW training programmes. There was also a limited focus on the entire life span of the DH ecosystem. We used relevant health worker training frameworks/models and digital competency frameworks to design a competency framework for the DH worker curriculum. The assessment of the existing curricula across the globe guided the establishment of the DH curriculum trends, and thus determined the new DH curriculum for the African region. We expect the DH curriculum to fill the DHW competency gaps that currently exist within the African region.

As a follow-up, our future work points to the need to re-assess the key DH worker competencies and expected outcomes for the African region once the in-service curriculum has been implemented; and the evaluation to adopt the use of eHealth technologies in support of decision-making and management at strategic and tactical levels and its success on completion.

Acknowledgements

We would like to thank WHO-AFRO for the support offered to the authors in production of this manuscript with regards to acceptance to use the Lesotho DH health managers training curriculum for the real-life setting.

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Journal of Health Informatics in Africa

ISSN: 2197-6902
DOI: http://dx.doi.org/10.12856/JHIA-2020-v7-i1

Publisher
Koegni eHealth, Innovation for Development e.V. Germany
Postfach 652166
D-22372 Hamburg, Germany
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