

Article

ICT framework to support a patient-centric approach in public healthcare: A case study of Malawi

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Although Information and Communication Technologies (ICTs) in the healthcare sector are extensively being deployed globally, they are not used effectively in developing countries. Many resource-poor countries face numerous challenges in implementing ICT interventions. For instance, most health applications deployed in Malawi are not user-centric. As a result, such ICT interventions do not benefit many health consumers. Furthermore, the dearth of a patient-centric ICT framework in Malawi renders eHealth and mHealth interventions less sustainable and less cost effective. The aim of this study is therefore to develop an ICT Framework that will support patient-centric healthcare services in the public health sector in Malawi. The comprehensive literature review and semi-structured interviews highlighted many challenges underlying ICT development in Malawi. This ICT framework was validated by five experts selected from different areas of expertise including mHealth application developers, ICT policy makers, and public health practitioners in Malawi. Results show that the framework is relevant, useful, and applicable within the context of Malawi's public health sector. The framework can also be implemented in various countries with similar settings. This paper builds on the proposal made earlier on the formulation of an ICT framework for patient-centric care in Malawi.

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Introduction

Despite the wide usage of Information and Communication Technologies (ICTs) in the healthcare sector in the world, many developing countries do not effectively utilize these new technologies. A number of eHealth and mHealth applications have been deployed within the Malawi healthcare context. Such initiatives include the development of the Health Management Information System (HMIS) across the country in 2002 and the web-based District Health Information Software (DHIS) in 2009. Currently, DHIS2 has been rolled in all the district hospitals of Malawi (Chikumba, 2017).

However, the Malawi public health sector faces a myriad of challenges, including the following: inadequate ICT infrastructure; poor maintenance strategies for ICT equipment in health facilities; lack of standards for smooth integration and interoperability of multiple systems; lack of policies to support governance of the ICT infrastructure; major gaps in ICT knowledge; and a lack of sustainability strategies for implemented or proposed systems (Ministry of Health - Ehealth Strategy, 2014; Ministry of Health and Population - Information Systems Strategy, 2017). These challenges are exacerbated by insufficient funding since the health budget for Malawi is heavily dependent upon donors (Borghi, Munthali, Million, & Martinez-Alvarez, 2018). As a result, such ICT interventions do not benefit many healthcare consumers. This means that many patients do not make full use of these ICT interventions. In fact, it is a concern that most of the data from HMIS is not used for decision making because the data are usually incorrect, incomplete, and untimely (Ministry of Health and Population - Information Systems Strategy, 2017). Despite having many mHealth projects in Malawi, most of these are not centrally run and coordinated by the government. As a result, these mobile health projects are duplicated, leading to a waste of resources. Some are even difficult to scale up to other locations since these mHealth projects only focus on specific areas of health interventions (Pankomera & van Greunen, 2018).

The lack of an ICT framework to support patient-centric healthcare services in Malawi renders the eHealth and mobile health interventions less sustainable and less cost effective. The aim of the study was therefore to develop an ICT Framework to support patient-centric healthcare services in the public health sector in Malawi. A patient-centric healthcare approach enables the patient to take full ownership responsibility of their own health and well-being. This approach strives to provide healthcare services based on the preferences, beliefs, and values of the healthcare consumer (Allen, Stewart, Roberts, & Sigal, 2017).

It is therefore envisaged that the proposed ICT framework will act like a reference tool for the deployment of ICT interventions for patient-centric care. This framework could also be applied in other developing countries that face similar challenges. Adhering to the ICT framework will also ensure that mHealth and eHealth interventions are scalable and sustainable. The next section therefore discusses the literature review of the research study.

Literature review

This section gives an overview of the context of the study, and the approaches to the healthcare services in the public health sector in Malawi.

Public health landscape in Malawi

The healthcare system in Malawi is mainly composed of the public health sector and private health sector. The private health sector is further divided into private-for-profit (PFP) and private-not-for-profit (PNFP) sectors. PFP comprises private hospitals, clinics, laboratories, pharmacies, and even traditional healers. PNFP sectors are usually religious institutions, non-governmental organisations (NGOs), statutory corporations, and companies. In Malawi, the Christian Health Association of Malawi (CHAM) is a prominent religious healthcare provider. It offers approximately 29% of all healthcare services in Malawi (Ministry of Health and Population - Information Systems Strategy, 2017). Unlike the public sector, most PFP providers charge user fees for their services.

There are four levels in the public health system in Malawi namely: community, primary, secondary, and tertiary and an established referral system links all these tiers (Ministry of Health, 2017). The Ministry of Health (MoH) is responsible for formulating policies for the healthcare system in Malawi. Most of the healthcare services are offered by the MoH. This implies that a small proportion of the population of Malawi receive healthcare services from the private sector. In each of the 28 districts in Malawi, hospitals provide secondary level care services.

ICT development underlying public healthcare in Malawi

Health Management Information System (HMIS)

An integrated routine health management information system (HMIS) was introduced in the public health sector in Malawi in 2002. The aim of the system was to integrate all routine data collection activities and to decentralize the generation of information activities (Chikumba, 2017). The integrated HMIS had the following subsystems: financial management information system (IFMIS); human resource management information system (HRMIS); logistic and supply management information system (LMIS); and physical assets management information system (PAMIS). Currently, the web-based district health information system (DHIS2) has been successfully rolled out to all the 28 districts in Malawi (Ministry of Health and Population - Information Systems Strategy, 2017).

Electronic medical records (EMRs) and electronic health records (EHRs)

A number of non-governmental organisations have developed a number of EMRs and EHRs to address specific needs of the health sectors in Malawi. Some of the modules developed so far, border on the management of the following areas: antiretroviral therapy (ART), outpatient department (OPD), general patient registration, antenatal care (ANC), maternity, and chronic care. Table 1 highlights some of EMRs and EHRs in Malawi and their respective locations where they are implemented.

Table 1: EMRs and EHRs in Malawi

No	Provider	EMRs and EHRs	Aim	Location
1	Baobab Trust (Baobab Health Trust 2020)	TB electronic health record system		<ul style="list-style-type: none"> Martin Preuss Centre -Bwaila hospital in Lilongwe

No	Provider	EMRs and EHRs	Aim	Location
			Improve the management and prevention of TB	<ul style="list-style-type: none"> • Mchinji district hospital • Ntchisi district hospital • Limbe health centre in Blantyre
		National ART system	Improve HIV/AIDS management, prevention, and treatment	<ul style="list-style-type: none"> • Health facilities, district • Central hospitals
		Antenatal care (ANC) system	Improve the continuum care of pregnant women	<ul style="list-style-type: none"> • Health facilities, district, • Central hospitals
		Electronic birth registration system	Capture births in health facilities	<ul style="list-style-type: none"> • Health facilities, district, • Central hospitals
		Laboratory information management system	Improve the management, storage, and reporting of lab data	
		HIV testing and counselling system	Improve HIV testing and counselling	<ul style="list-style-type: none"> • Health facilities, district, • Central hospitals
		Electronic death registration system	Improve the recording of certified deaths	<ul style="list-style-type: none"> • Health facilities, district, and central hospitals
2	Luke International (Luke International - Malawi 2020)	ANC HIV Compute Radiography	Improve the management of HIV, radiology, and antenatal services	<ul style="list-style-type: none"> • Mzuzu Central Hospital • Rumphu Hospital
3	Medecins Sans Frontieres – Malawi (Medecins Sans Frontieres - Malawi 2020)	Circle of care system	Improve the management of HIV and TB	<ul style="list-style-type: none"> • Chiradzulu, • Nsanje. • Lilongwe • Dedza, • Blantyre, • Zalewa
4	Nkhoma Mission Hospital(Memory Business Solutions 2018)	AfyaPro 2.0 connected Care system	Improve patient record management and billing processes	<ul style="list-style-type: none"> • Nkhoma Hospital in Lilongwe
5	JSI (Gilbert et al., 2020)	Logistics Management Information Systems	Improve the procurement of medical goods and services	<ul style="list-style-type: none"> • Some districts in Malawi

Mobile health systems

There are also mobile health systems that have been deployed to complement EMRS and HMIS. MHealth applications target various areas of health interventions such as maternal and child health, supply chain management, women's health, and childcare (Groupe Speciale Mobile Association, 2014). Table 2 illustrates names of mHealth projects, mode of delivery, target audience of the mHealth project, and reported benefits realised from the system (Malanga & Chigona, 2018; Pankomera & van Greunen, 2018). Furthermore, Table 2 depicts that SMS is a predominantly mode of delivery of health information for mHealth applications.

Table 2: MHealth Projects in Malawi

Name of mHealth	Mode of Delivery	Target Audience	Benefits
Chipatala Cha Pa Foni [CCPF] (Health Centre by Phone (Village Reach 2020)	Voice, SMS, Apps	Pregnant Women, community health workers, caregivers	<ul style="list-style-type: none"> • Improved antenatal care • Increased use of bed nets • Early initiation for breastfeeding • Increased knowledge of maternal health • Increased home and family-based care
RapidSMS: Nutrition Surveillance Project (Clinton Health Access, 2020)	SMS, Web	Nutrition Managers, Health Surveillance Assistants (HSAs)	<ul style="list-style-type: none"> • Improved nutrition
Community Case management (Rodríguez, Banda, & Namakhoma, 2015)	Apps	Community Health Workers (CHWS)	<ul style="list-style-type: none"> • Improved drug consumption and stock outs • Increased satisfaction from caregivers about services
RemindMI (Groupe Speciale Mobile Association, 2014)	SMS	HSAs, Mothers through HSAs	<ul style="list-style-type: none"> • Increased in timely attendance of hospital by patients • Reduction in missed or delayed client appointments
The Malawi K4Health Mobile Learning Pilot (Cunningham et al., 2016)	SMS	CHWs	<ul style="list-style-type: none"> • Timely reporting of side effects • Timely information about supervisory support visits • Teleconsulting
Partners in Health – Yendanefe (Partners in Health 2020)	SMS and Apps	CHWs	<ul style="list-style-type: none"> • Early detection, referral, and treatment of HIV, malnutrition and maternal health

Challenges in implementing HMIS in Malawi

Implementation of HMIS and mobile health projects suffer from a couple of challenges as discussed in the subsequent sections.

1. Inadequate monitoring and evaluation health information system (MEHIS) human resources. There are only nine positions to monitor the complex HMIS at the national level. Most established positions remain vacant. Furthermore, training for new HMIS staff is also inadequate (Ministry of Health and Population - Information Systems Strategy, 2017).
2. Over-reliance on manual data collection tools. Over 90% of registers and data collection tools in various health facilities in Malawi are paper-based (Ministry of Health and Population - Information Systems Strategy, 2017). Paper-based data collection tools are bulky, inefficient, inconvenient, and costly.
3. Lack of coordination in implementing MEHIS activity. Most activities within the HMIS are not harmoniously coordinated. This results in misallocation of resources and duplication of activities. There are also parallel reporting structures that lead to data redundancy and interoperability problems (Ministry of Health, 2017).
4. Poor data quality. There is evidence that data from the DHIS2 are not usually used for decision making because these data are inaccurate and sometime unavailable. There are still some discrepancies between the data in registers or reporting forms and the data in the DHIS2 (Ministry of Health and Population - Information Systems Strategy, 2017; O'Hagan et al., 2017).

Challenges in mobile health systems

1. Poor ICT infrastructure. There is still a relatively low level of mobile penetration with 39.01% mobile subscriptions in 2018 in Malawi (Statista Inc., 2020). Additionally, poor network coverage and high internet tariffs negatively affect the accessibility of mHealth applications by health consumers and providers (Pankomera & van Greunen, 2018).
2. Lack of coordination. Most pilot mobile health projects are not centrally managed by the Government. As a consequence, their results are not propagated to other projects. Moreover, fragmentation in mHealth service delivery leads to inefficient use and misallocation of scarce resources. (Pankomera & van Greunen, 2018).
3. Lack of human skills and development. Inadequate skilled personnel such as systems analysts and programmers still remain a challenge in developing mHealth applications. Reliance on expatriates compromises the sustainability of projects (Ministry of Health and Population - Human Resources, 2018; Pankomera & van Greunen, 2018).

4. Cultural barriers. Change of mindset due to cultural values has an impact on adopting mHealth technology. For instance, during the assessment of Chipatala project, it was highlighted that women were reluctant to reveal their estimated delivery date of their pregnancy to a person they did not know. This was likely to have an impact on the adoption of the mHealth project (Malanga & Chigona, 2018).
5. Intermittent power supply. Most rural areas, where mHealth projects are, have no electricity. Furthermore, the supply of electricity in Malawi is not reliable. The intermittent power supply has a negative impact on the operations of mHealth applications (Malanga & Chigona, 2018; Pankomera & van Greunen, 2018).

Patient health care approaches

There are many approaches to providing quality care services to healthcare consumers. These approaches define the level of relationships between the patient and a healthcare provider. Three approaches of patient health care discussed in the subsequent sections, are (1) provider or physician centred approach, (2) patient-centred care, and (3) patient-centric care.

The provider or physician centred care

This healthcare approach is paternalistic in which the physician assumes a leading role in treating a patient (Franzen, 2017). The assumption is that the health professionals have the medical knowledge and as such they can make the best decision for their patients. This healthcare approach is predominantly being used in Malawi.

Patient-centred care

This approach aims at providing healthcare services based on the values, preferences, and needs of a patient (Fix et al., 2018). The following are the dimensions of patient-centred care: coordination and integration of care, patient empowerment with information, involvement of family and friends in patients care, physical and emotional support for patients (Picker, 2015).

Patient-centric care

Patient-centricity is a dynamic process through which the patient regulates the flow of information via multiple pathways in order to exercise choices that are consistent with their preferences, values, and beliefs (Leecher, 2012; Robbins, Curro, & Fox, 2013). This approach is different from the patient-centred care in which the patient takes the ownership of their health and well-being. For the purposes of this study, the patient-centric approach is more than patient-centred care that embraces the dynamic and continuous doctor and patient relationship with a focus on preventive care rather curative care (Pankomera & van Greunen, 2017).

Family-centred care

This approach provides healthcare services to children and members of the family as a whole entity (Uniacke, Browne, & Shields, 2018).

Woman-centred care

The woman-centred care focuses on the needs of a woman such as antenatal care, reproductive health (Floris, Irion, Bonnet, Politis Mercier, & de Labrusse, 2018).

Relationship-centred care

In general, relationship-centred care promotes the caring of individuals so that they feel a sense of security, continuity, belonging, and worth in a relationship (Soklaridis, Ravitz, Adler Nevo, & Lieff, 2016).

Benefits of patient-centric care

This study adopts the patient-centric approach owing to its various benefits. Firstly, the adoption of patient-centric care promotes health literacy since a patient is empowered to make informed health decisions after understanding basic health information (Uddin, 2016). Second, shared decision-making entails that patients become active partners with health professionals in choosing a particular healthcare option (Vahdat, Hamzehgardeshi, Hessam, & Hamzehgardeshi, 2014). Third, the notion of self-care enables a patient to take an active role in the management of own health and wellbeing. An active healthcare consumer becomes well informed and therefore makes informed decisions about their own health (Pankomera & van Greunen, 2016). Fourth, patient safety is also considered as healthcare providers can work in collaboration with patients to reduce adverse outcomes. Fifth, the patient-centric care model advocates equal accessibility of healthcare services irrespective of one's affordability to pay for such services. For instance, new modes of communication such as e-mails, video conferencing, and mobile phones have assisted to widen access to healthcare services. These modes of communication have subsequently promoted patient experience in such a way that patients get engaged in developing, planning and implementing healthcare interventions (Rigby et al., 2015),

Theoretical background

The development of the proposed ICT framework was based upon a combination of integrated patient-centred model (ICD) and user-centred design (UCD) model.

The integrated patient-centred (ICD)

This model has a number of aspects of dimensions namely principles, enablers, and activities. First, the principles of the model include the essential characteristics of the clinician, good clinician-patient relationship, a patient being treated as a unique person, recognition of patient's biological, psychological, and social characteristics. Second, the enabler aspect of the model comprises the following: available access to care, better coordination and continuity of care, teamwork and teambuilding, integration of medical and non-medical care to better support the patient and clinician-patient communication. Third, the activities aspect incorporates the sharing of knowledge and information, patient involvement in care, families, and friends involvement to support the patient care, patient

empowerment, physical and emotional support (Scholl, Zill, Härter, & Dirmaier, 2014). The motivation for choosing ICD in this study is that it focuses on the integration of patient-centred health services thereby making healthcare delivery more accessible, sustainable, efficient, and cost effective.

The User Centred Design (UCD)

This framework is usually used as the basis for the development of useful and usable eHealth or mHealth applications. This human-centred design process focuses on the user needs and requirements as they are involved at each stage of the design process. This approach ensures that tasks and actions are easily determined and visible to the users. The basic steps of the UCD are identifying a need; specifying the context of use; specifying requirements; developing and evaluating design solutions (US Dept. of Health and Human Services, 2018).). UCD was used in this study because it focuses on the user when designing health applications thereby making them more useful and usable.

The proposed ICT framework is expected to support the patient-centric healthcare services in the Malawi public health sector. It is therefore envisaged that this framework will be used by software developers, policy makers, and regulators to ensure that ICT interventions in the health sector are patient-centric. Furthermore, the framework can also act as a model for other ICT interventions with similar settings in the healthcare around the world. The next section discusses the methodology that was followed during the research study.

Methodology

This section endeavours to elucidate the research objectives and the research design process of the research study. It also discusses data collection methods and data analysis techniques that were used during the research.

Research Objectives

The primary objective of this research was to develop an ICT framework that can support patient-centric healthcare approach in Malawi. To accomplish the aforementioned primary research objective, the following secondary research questions were formulated:

- a) *What are the challenges underlying the healthcare ICT development in the public sector in Malawi?*
- b) *What are the components of an ICT framework that can support a patient-centric approach in Malawi?*

Methods

The research followed the philosophy and paradigm of design science. By definition, design science is the paradigm that produces an artifact by providing a technological solution to a social problem within a particular context (Vaishnavi & Kuechler, 2015).

Semi-structured interviews and comprehensive literature review were used to collect qualitative data. Thematic content analysis technique was employed to analyze data that

were obtained from semi-structured interviews. The ICT framework for patient-centric healthcare services is therefore the output artifact, which focuses on technology-based solutions within the public health sector in Malawi. To ensure the rigor of the ICT framework, the artifact was validated by experts who had diverse backgrounds. The paper subsequently serves as the last step of the design science process to communicate the artifact to a technology-oriented audience in the form of a peer reviewed publication (Vaishnavi & Kuechler, 2015).

Research Design Process

The research design process is divided into four major phases namely problem identification, framework development, evaluation, and conclusion (Vaishnavi & Kuechler, 2015). Figure 1 depicts the research design process that follows the concept of design science in which each step is iterative. The figure shows that each of the objectives has to iteratively undergo the following phases: awareness, suggestion, and development. As a logical argumentation, abduction was used in the awareness and suggestion phase while deduction was employed in the development phase. Inductive reasoning was used to understand the contextual health landscape in the public health sector in Malawi while deductive reasoning used logical premises to reach a conclusion that informed the development of an ICT framework.

Furthermore, the ICT framework development followed 8 steps as proposed by (Jabareen, 2009). The following are the steps employed in constructing a conceptual ICT framework: mapping the selected data sources; extensive reading and categorizing of the selected data; identifying and naming concepts; deconstructing and categorizing the concepts; integrating concepts; synthesis and re-synthesis; ensuring it all make sense; validating the conceptual framework; and rethinking the conceptual framework. These steps are also illustrated in Figure 2 and are also further explained in subsequent sections.

Furthermore, the ICT framework evaluation tool was developed and administered online by the experts. This tool consisted of major components of the ICT framework, such as contextual setting, legal setting, and non-functional attributes of the artifact. The experts were requested to rate the phases and their related activities based on the importance of the component from their point of view. They were also given an option to recommend either to add or remove some components from the proposed ICT framework.

Data Collection

Qualitative data were collected to achieve the development of the ICT framework which was proposed to support patient-centric healthcare services. The first step of mapping data sources of the ICT framework used comprehensive literature and semi-structured interviews with a total of 16 participants. A profile of participants is attached in Appendix 1 and a sample of questions in Appendix 2. The participants were drawn from health providers, policy makers, software developers and ICT regulators. A purposeful sampling technique was used to select the participants. This technique was chosen because of the varying backgrounds and expertise of the participants. This purposeful sampling was combined with a snowball sampling in which some experts were allowed to suggest more participants that had a particular expertise in a specific field.

Before the interviews were conducted, informed consent was requested from the participants. The interviews were audio recorded by the researcher. Additional written notes were also taken. On average, each interview took approximately 30 minutes. The participants for the interviews were drawn from all three regions of the country namely the northern region, central region, and southern region. The questions during the interview comprised four sections. The first section was on the biographical data included the experience levels, areas of expertise and highest academic qualification. The next section solicited information on the challenges underlying the ICT development in the public healthcare sector. This was followed by a section on the status of electronic health and mobile health applications in the public health sector in Malawi. Another section sought information about the requirements of an ICT framework. The last section bordered on the availability and feasibility of patient-centric healthcare services in Malawi.

Results and Findings

This section explains the process of the formulation of the ICT framework. The major components of the ICT framework are further discussed.

Data Analysis

Thematic analysis was used to analyze the qualitative data of the research study. This analysis followed the six steps of thematic analysis ((Braun & Clarke, 2006). Audio recorded interviews were transcribed. Each participant was given a code identifier to ensure anonymity. The duration for transcribing each interview was approximately one and half hours.

Transcriptions were typed in Microsoft Word 2016 and later imported into a qualitative data analysis software called Atlas.ti version 7.5.10. The analysis process started with the identification of preliminary codes, which indicated the context of conversation. These preliminary codes were combined or split depending on their relevance to the research questions of the study. This phase produced more codes, subthemes, and themes, which were later redefined or renamed. The frequency of each code was important as it determined its grounding in the study. The whole coding process was iterated to ensure accuracy and completeness of the themes. This process was further validated by an independent peer researcher.

Challenges underlying ICT development in public health care

The comprehensive literature study and findings from the semi-structured interviews highlighted many challenges underlying the ICT development in the public health sector.

First, there is inadequate human capacity to sustain ICT interventions. One participant who leads a team of ICT health applications in a non-governmental organization stated: *“there are few systems analysts and programmers to develop healthcare systems.”*

Participant 8 (P8).

Second, inadequate ICT skills for healthcare and medical professionals compromise the quality of delivery healthcare services. This challenge was echoed by another interviewee

who said “Sometimes, ICT is taken as a barrier to the operations of a healthcare practitioner” (P2).

Third, there is a gross inadequate funding in the public health sector as was bemoaned by another participant heading one of the ICT sections in the ministry of health, “...the funding is not enough, and sometimes it comes haphazardly.” This interviewee further bemoaned that “...the lack of funding contributes to adequate ICT infrastructure and equipment...”(P6).

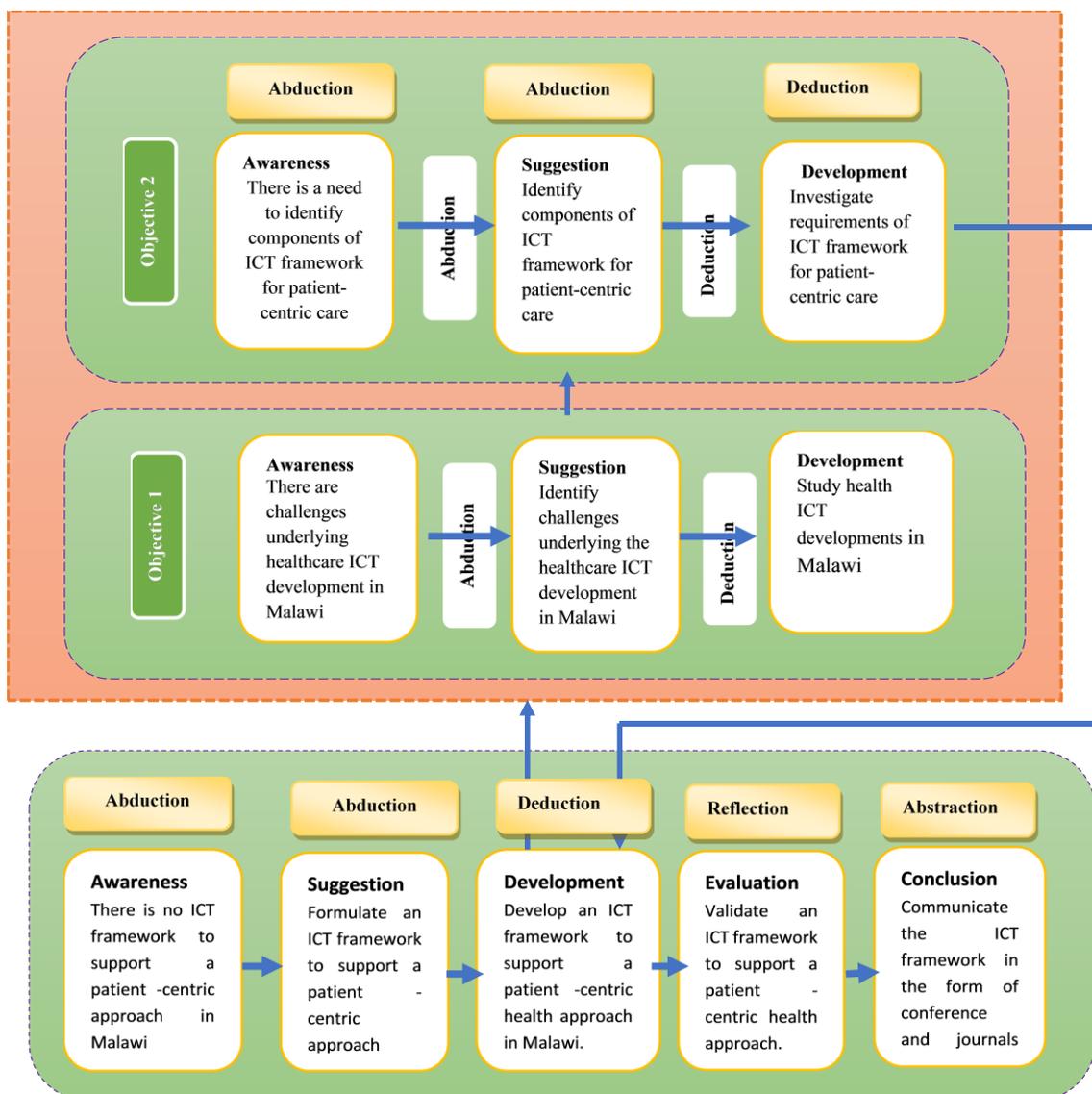


Figure 1 Research Design Process adapted from (Vaishnavi & Kuechler, 2015)

Fourth, there is a lack of coordination in eHealth and mHealth interventions. According to one interviewee, *“NGOs ICT interventions are localized and have difficulties in rolling out to other communities and therefore there is no continuity when a pilot project is phased out” (P6).*

Fifth, there is unreliable power supply. A user of the health information management system at a central hospital said, *“When there is no power, we do not do any work here, and the system is not connected to the backup power.”*

Six, there are no standards for data, security, and architecture for interoperability of multiple systems. One interviewer commented *“We have many systems that do not talk to each other...” (P2).*

Seventh, there is a resistance to embrace new technology. One interviewee said, *“There is a mentality among the health professionals and others that the ICT intervention may take up their jobs.”* A number of participants indicated that ICT can be a catalytic factor to enhance patient satisfaction in the delivery of healthcare services. One participant said, *“We need to have systems that are friendly and easy to use, just as in perceived ease of use of applications.”* On the sustainability of mHealth and health projects another interviewee suggested that, *“there is a need for a regulatory framework to evaluate projects” (P7).*

Emerging major themes

The analysis produced broad themes such as contextual factors, legal frameworks, health applications, patient-centric care services, monitoring and evaluation.

Table 3. Themes and subthemes for requirements of the ICT framework

Main theme	Subtheme	Categories
Context	• Technology	<ul style="list-style-type: none"> • ICT infrastructure • Technical skills (human capacity) • Research and education technology • Knowledge management tools • Health facilities and equipment • Availability of technological facilities
	• Social	<ul style="list-style-type: none"> • Literacy/education levels • Acceptance of new technological change • Population growth rate • Health and safety awareness • Cultural values, attitude, and beliefs • Ethics
	• Economical	<ul style="list-style-type: none"> • Funding levels • Poverty levels • Affordability of medical healthcare scheme • Employment opportunities
	• Political	<ul style="list-style-type: none"> • Political will/ support

Main theme	Subtheme	Categories
		<ul style="list-style-type: none"> • Political stability • Corruption levels
Legal framework	<ul style="list-style-type: none"> • Policies • Strategies • Standards • Regulation • Legislation 	<ul style="list-style-type: none"> • ICT policies • EHealth strategies • MHealth strategies • Interoperability standards • Regulatory bodies • Health and safety laws • Privacy and security laws
Health Applications	<ul style="list-style-type: none"> • Non -functional attributes 	<ul style="list-style-type: none"> • Accessibility, integrity, accuracy, uniqueness, availability, simplicity, flexibility, reliability, scalability, mobility • robustness, usefulness, usability, auditability, valuable
	<ul style="list-style-type: none"> • Applications 	<ul style="list-style-type: none"> • Portal, telemedicine • Electronic medical records • Personal health records • Electronic health records
Stakeholder	<ul style="list-style-type: none"> • Policy makers • ICT regulators • Monitoring and evaluation team • System developers • Health consumer • Health provider 	<ul style="list-style-type: none"> • ICT and health policy makers • Malawi communications and regulatory authority
Patient-centric services	<ul style="list-style-type: none"> • Principles 	<ul style="list-style-type: none"> • Essential characters of a clinician • Patient being treated as a unique person • Recognition of patient's biopsychosocial characteristics • clinician-patient relationship
	<ul style="list-style-type: none"> • Enabler 	<ul style="list-style-type: none"> • Access to care • Better coordination and continuity • Teamwork and teambuilding • Integration of medical and non-medical care • Clinician-patient communication
	<ul style="list-style-type: none"> • Activities 	<ul style="list-style-type: none"> • Sharing of knowledge and information

Main theme	Subtheme	Categories
		<ul style="list-style-type: none"> • Patient empowerment • Physical and emotional support • Families and friends' support care • Patient involvement in care

Development of the Framework

The following steps describe how the framework was formulated as illustrated in Figure 2.

Step 1: Map the selected data source

The semi-structured interview was used to gather the primary source of data while a comprehensive literature review was a secondary method. It is noteworthy that a combination of literature review and semi-structured interviews were purposely designed to ensure data triangulation. Coupled with the researcher's personal experience and technical background, existing theories were used in formulating a patient-centric ICT framework for the public healthcare sector in Malawi.

Step 2: Reading and categorising of data.

Data from a comprehensive literature review were compared with that from the semi structured interviews to answer the research question. The resultant data were further categorised according to its relevance and importance. Some preliminary emerged categories are challenges underlying ICT development in the public healthcare sector in Malawi; and components requirements for an ICT framework to support patient-centric healthcare services in Malawi. These preliminary categories provided vital inputs into the formulation of an ICT framework for patient-centric healthcare services in the public healthcare sector in Malawi.

Step 3: Identifying and naming the concepts

This step involves re-reading the data sources to understand various categories and emerging concepts. It is an iterative process that requires going through previous steps again.

Step 4: Deconstructing and categorizing the concepts

Analysis of various concepts from the previous steps culminated in a number of different themes and subthemes. In this case, names, attributes, assumptions, roles, and descriptions of concepts and categories were further refined.

Step 5: Integrating concepts

The main themes from the thematic analysis of the semi-structured interviews were subsequently compared with factors from the comprehensive literature review. Table 3 outlines a summary of some themes and subthemes for the ICT framework that can support patient-centric health services in Malawi. Based on similarities and differences, various themes were merged into major concepts as depicted in Table 4.

Step 6: Synthesising and re-synthesising to make sense of the data.

The major themes and concepts from the previous step were synthesized to formulate the proposed ICT framework. This was an iterative process aiming at making sense from the data so as to create the aforementioned theoretical framework (Jabareen, 2009). The Figure 3 depicts the proposed ICT framework for the support of patient-centric healthcare services.

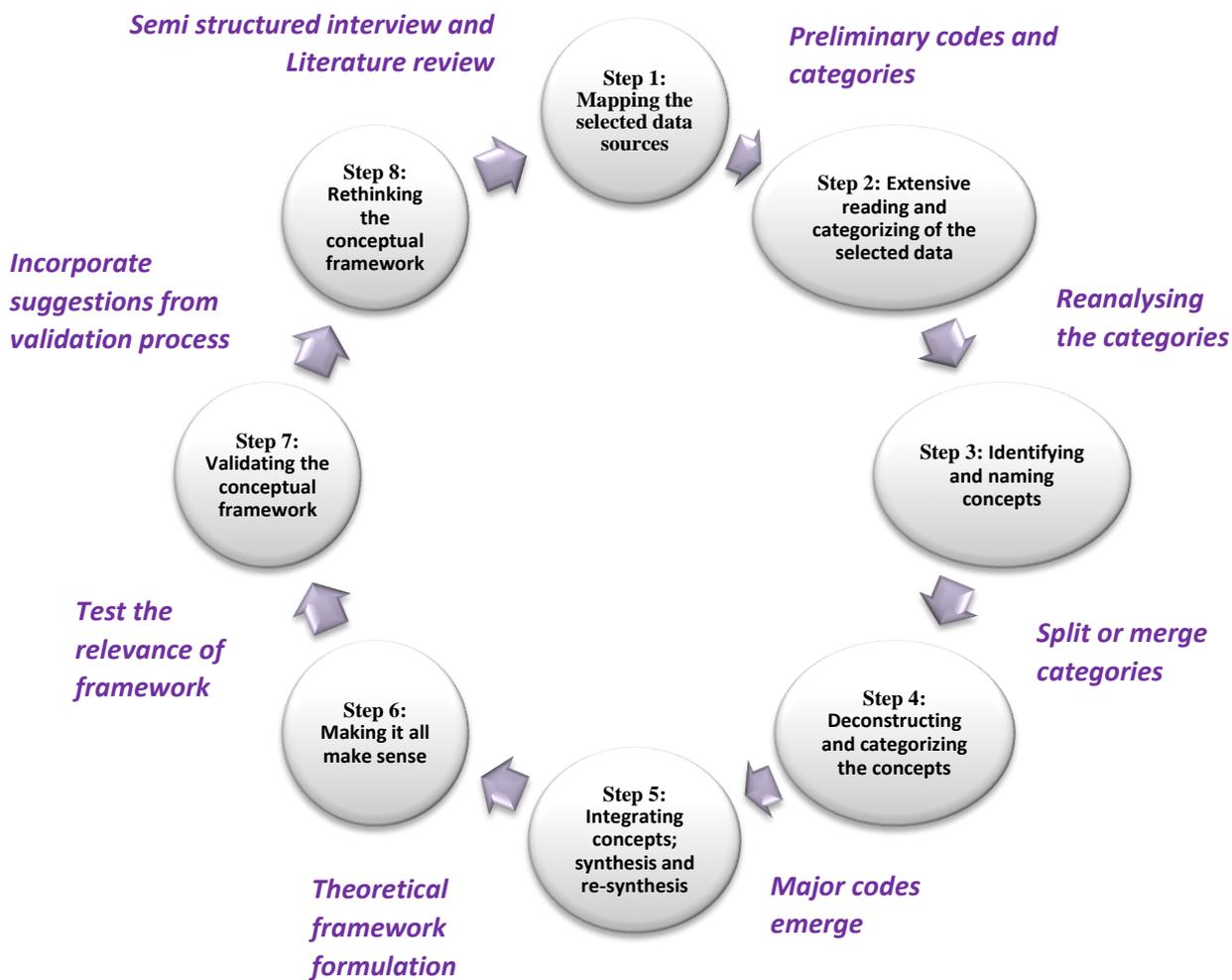


Figure 2: Research process for developing ICT framework (Jabareen, 2009)

Step 7: Validating the conceptual framework

This step ensures that the proposed framework is relevant and useful so that it meets the needs of the stakeholders within the context of the study. Most experts recommended that the framework is relevant. A few experts suggested that some components were not very important. Some of the features suggested to be added were cultural aspects, religious aspects, and means of sustaining health applications. These features were put into the framework under some relevant major components. For example, the cultural aspect was incorporated into the contextual component of the framework. Furthermore, although there were some disagreements on political will, over 60% agreed that it has a significant role in health systems. With a number of suggested modifications, the experts unanimously agreed that the framework was relevant, useful, and applicable within the setting of Malawi.

Step 8: Rethinking the conceptual framework

The suggestions from the validation process were then analyzed and incorporated into the final ICT framework. This dynamic framework can also be customised to be redeployed in developing countries with similar settings.

Table 4: Emerging major concepts

Major concepts	Subthemes
Infrastructural context	<ul style="list-style-type: none"> • Technology • Social • Economics • Political
Statutory and Legal framework	<ul style="list-style-type: none"> • Policies • Strategies • Standards • Regulation • Legislation
Health Applications	<ul style="list-style-type: none"> • Non -functional attributes • MHealth applications • DHIS2
Stakeholder	<ul style="list-style-type: none"> • Policy makers • ICT regulators • Monitoring and evaluation team • System developers • Health consumer • Health provider
Patient-centric services	<ul style="list-style-type: none"> • Principles (Values) • Enabler • Activities

Discussion

This section gives a description of the proposed framework as depicted in Figure 3. The ICT framework has six components: Context, legal framework, health application, patient-centric services, monitoring and evaluation and stakeholders. These are further discussed in detail in the subsequent subsections.

Components of the Framework

Context

The contextual setting in which the ICT framework operates, consists of factors such as technological factors, social factors, economic factors, and political factors.

First, the technological factors such as ICT infrastructure; technical skills (human capacity); research and education technology; knowledge management tools; health facilities equipment and availability of technological facilities contribute to the success of ICT interventions in public health sector. These technological factors are necessary for the provision of quality healthcare delivery. Second, social factors include: literacy levels of the citizenry to interpret and analyze health information; acceptance level of new technological change; population growth rate; health and safety awareness; cultural values; attitude and beliefs; and ethics. For instance, patient-centric healthcare approach ensures that patients are treated according to their own values, attitude and beliefs thereby enhancing patient care satisfaction and experience (Bhandari & Snowdon, 2012; Leecher, 2012). Third, economic factors encompass the following: funding levels; poverty levels; affordability of medical healthcare scheme; and employment opportunities. For instance, studies have shown that there is a strong correlation between poverty prevalence and mortality (Hodgetts & Stolte, 2017). Fourth, political factors include political will, political stability, and corruption levels. For example, political will plays a role in improving access to healthcare services especially in developing countries (Oronje, Murunga, Musila, & Zulu, 2013). In general, the aforementioned are essentially the basic requirements for successful ICT interventions of patient-centric healthcare services.

Legal and regulatory framework

This component ensures that the following: ICT policies; eHealth and mHealth strategies; interoperability standards; regulatory frameworks; health and safety laws; and privacy and security laws enable efficient and secure utilization of ICT interventions in the public health sector. Policy and legal frameworks protect health information from unauthorized access. It may also enforce penalties in case of misuse and abuse of patient information. In addition, policy and legal frameworks may ensure the adherence to professional ethics as they may guide patients and healthcare practitioner on how data can be collected, stored, and reported.

Health applications

There are many health applications, such as: portal; telemedicine; electronic medical records (EMR); personal health records (PHR); and electronic health records (EHR); that

may offer various health services to patients. A portal provides a platform for patients to access their health information on the web. Telemedicine involves the diagnosis and treatment of patient over a distance by means of telecommunication technology. EMRs keep the medical and treatment history of a patient at one healthcare provider. EHR enables the sharing of EMRs among various healthcare providers. While EHRs and EMRs are controlled by healthcare providers, PHRs enable the patient to control and manage their own personal health information (Heart, Ben-Assuli, & Shabtai, 2017).

For these health applications to offer patient-centric healthcare services, they should have the following quality attributes: accessibility; integrity, accuracy; uniqueness; availability; simplicity; flexibility; reliability; scalability; mobility; robustness; usefulness; usability; and auditability, among others (Pettus, Vanderveen, Canfield, & Schad, 2017). Such systems must be accessible by authorized users ubiquitously. A health information system of high integrity must provide trustworthy and accurate information which must be readily available when it is needed. Besides providing security control measures to circumvent unauthorized access to information, patient-centric systems must be usable and useful.

Patient centric services

The aim of the ICT framework is to ensure that healthcare services are patient-centric. This means that a patient must be treated as a unique person with personal, biological, and social characteristics. With patient-centric approach, healthcare practitioners need to have good communication skills, empathy, and medical competency. A good communication relationship between a patient and healthcare practitioner cements mutual trust. It is also highly important that patients' needs, preferences, values, beliefs, and expectations are considered when providing healthcare services (Robbins et al., 2013). Unlike the provider-centred care, the provision of patient-centric healthcare services is a continuous dynamic interaction between the patient and the healthcare practitioner over a patient's whole life. It is a collaborative teamwork that involves patients, family members, friends for physical comfort and emotional support in the provision of healthcare. This means that a patient must be empowered with information to be able to make an informed decision about their own health and wellbeing.

Monitoring and evaluation

Monitoring and evaluation teams must ensure that standards, policies, and laws are adhered to. This is a critical and continuous assessment phase during the implementation of an ICT framework. It involves a collaboration among various key stakeholders, such as healthcare providers, health applications developers, patients, and policy makers to make sure that health services meet the needs, preferences, beliefs, values, and expectations of the patients.

Stakeholders

Many stakeholders must collaborate to ensure that all standards and needs are met. Such stakeholders are ICT and health policy makers and Malawi communications and regulatory authority (MACRA), among others. These stakeholders play various pivotal roles in an effort to make the provision of healthcare services more patient-centric. For instance, the MoH is mandated to develop and review health policies and standards in

collaboration with other stakeholders in Malawi. On the other hand, MACRA regulates the broadcasting, cellular, and internet services in Malawi.

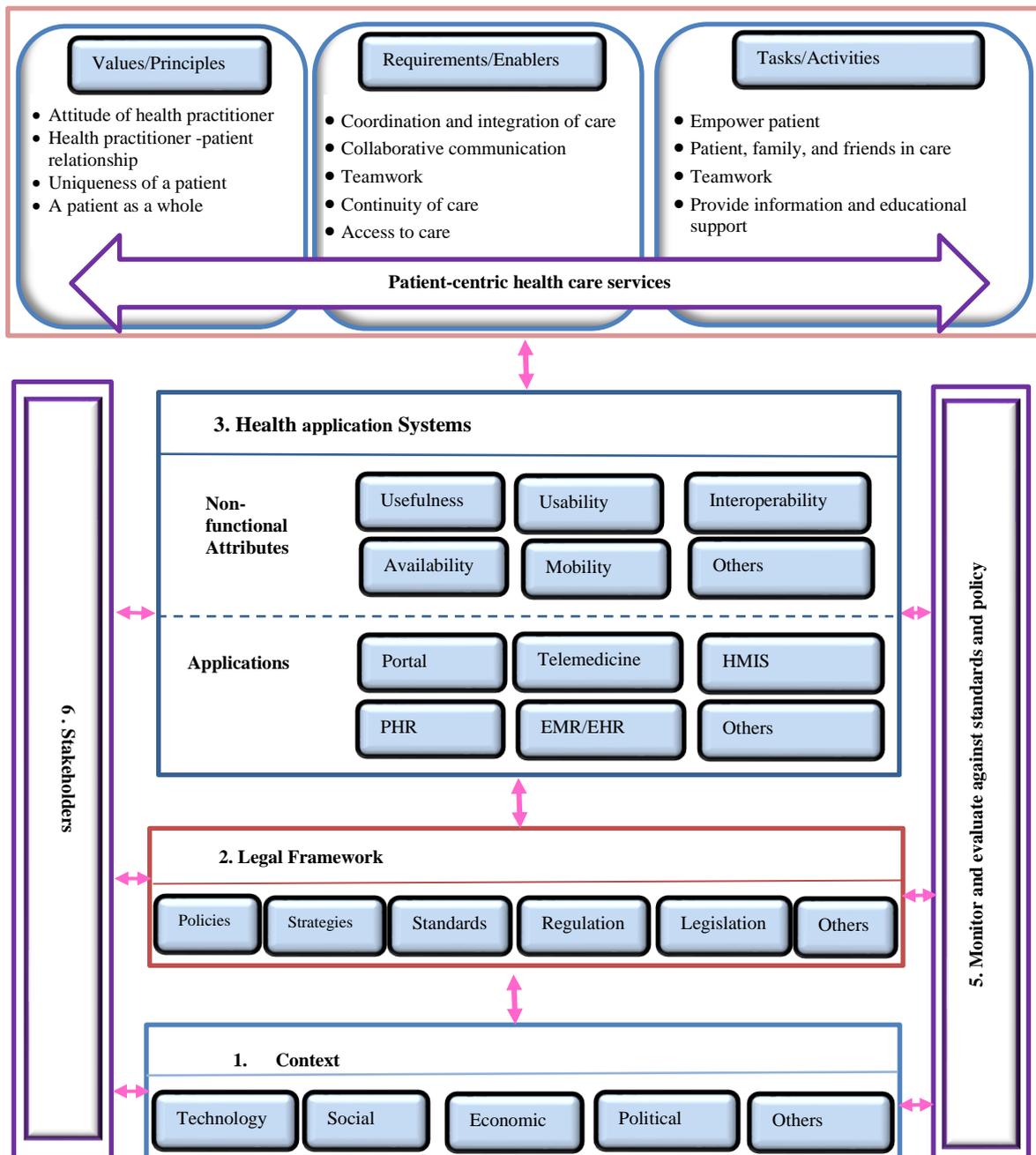


Figure 3: Proposed ICT framework to support patient centric services

Interrelationships of the components of the ICT

Central to the ICT framework is the provision of patient-centric services. These are the services that consider the values, principles, and preferences of the healthcare consumer. For such services to be effective, there are many players from various aspects. There exists a number of relationships among the components of the ICT framework as depicted in Figure 4.

MHealth and eHealth applications must be designed in a such way that it facilitates a better provision of quality patient-centric care. They must be developed specifically for the patient. For instance, one interviewee suggested that mobile health applications must be designed in the language that can be understood by the local person in the remote areas. Continuous collaboration among policy makers, system developers, monitoring and evaluation teams, and the patients need to be put in place.

There is a strong relationship between the legal framework and the patient-centric healthcare services. Public health laws and ethics ensure that both the healthcare consumer and healthcare provider are safe in the course of providing healthcare services. Health and medical ethics must be adhered to. More so, violations of professional code of ethics can be systematically addressed. Policies need to be formulated to benefit the healthcare consumer that the healthcare provider.

The infrastructural context is related to the provision of patient-centric healthcare services. The availability of mobile networks, for instance, enables patients to access mHealth applications in rural areas where it is difficult even to consult a healthcare practitioner. The availability of health clinics within a short distance has provided many healthcare consumers with better quality and more convenient healthcare services. The quality of healthcare professionals and health literacy of patients also have a great impact on the delivery of patient-centric healthcare services. Both healthcare providers and healthcare consumers need to be empowered with necessary information, if both players have to mutual benefit from a patient-centric healthcare approach.

Holistically, various key stakeholders are involved in ensuring that the delivery of healthcare services is more patient-centric. There is a need for close collaboration among various key stakeholders, including: healthcare consumers; healthcare providers; policy makers; health and medical experts; health application developers; and monitoring and evaluation teams. Noteworthy is to mention that the monitoring and evaluations team is related to the components of the framework as it ensures that all the activities conform to the established standards, norms, and best practices

Validation of the framework

The ICT framework was validated by five experts selected from different areas of expertise including mHealth application developers, ICT policy makers, and public health practitioners. The aim of this validation process was to determine the relevance and usefulness of the proposed framework in a resource constrained setting, such as Malawi. Much as the experts agreed with most of the components of the framework, emphasis was made on the sustainability of mHealth and eHealth applications. Appendix 2 provides a

profile of the validation experts. Table 5 gives a summary of the responses by the experts who unanimously agreed that the framework was relevant and applicable.

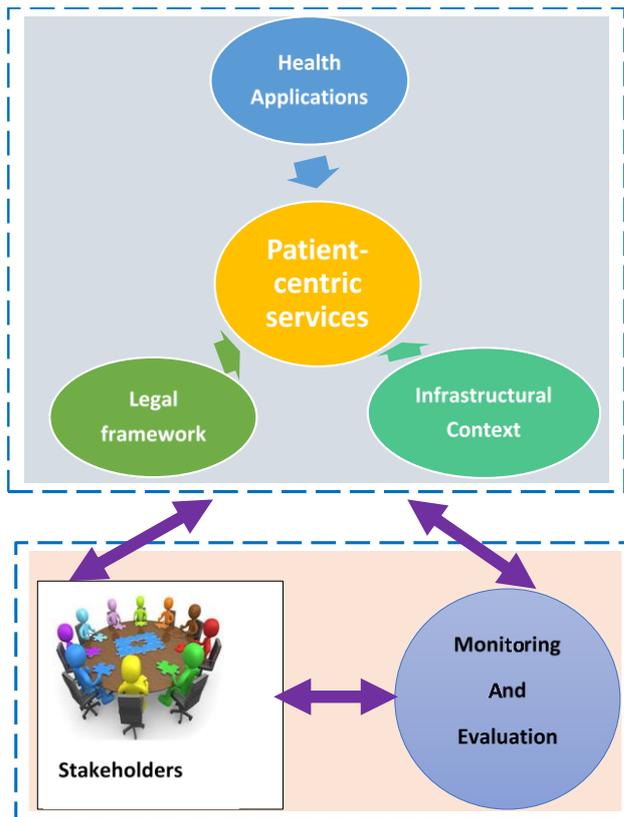


Figure 4: Interrelationships of components of ICT framework (Researcher’s design)

Uniqueness of the ICT Framework

Context

Many health information frameworks have been developed, but this ICT framework will be operational in a unique context of the public health sector in Malawi. It was specifically designed for a resource constrained setting. Malawi public healthcare sector suffers from a myriad of ICT challenges. It also heavily relies on donor support. There are also low literacy levels in addition to inadequate health and ICT personnel. While providing patient-centric healthcare services, the ICT framework emphasises on continuous monitoring and evaluating the managing of resources so that health applications become easily sustainable and scalable.

Design Science as a methodology

This ICT Framework used design science as methodology, which is rigorous in nature as each step is iterative. It is a methodology which is self-validating because of its iterative phases. There are many outputs of design science, but the output of this research study was the patient-centric ICT framework for the public health sector in Malawi. The iterative steps involved: the identification of the problem in Malawi’s healthcare landscape; defining objectives of the research study; designing and developing an ICT framework; and evaluating and disseminating the research output. This publication forms the last step of communicating the output of design science to the technology-oriented audience.

Table 5: Summary of responses from experts

Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD)

	SA	A	D	SD
Efficient	✓✓✓	✓✓		
Operational	✓✓	✓✓✓		
Well designed	✓	✓✓✓✓		
Relevant	✓✓	✓✓✓		
Useful	✓✓✓	✓✓		
Applicable	✓✓✓	✓✓		
Valuable		✓✓✓✓✓		
Customisable	✓	✓✓✓✓		
Adaptable	✓	✓✓✓✓		
Formulate the assessment criteria	✓			
Good requirements	✓✓	✓✓✓		
Requires improvement		✓✓✓✓	✓	
Project leadership skills	✓			
Involvement of various stakeholders	✓			
Evaluation	✓			
Maintenance	✓			

Components of the Framework

Data triangulation from comprehensive literature and semi-structured interviews conducted in Malawi produced a number of components that informed the ICT framework. Interviews were transcribed. Codes were gleaned and merged into major themes. This implies that the components for the framework were obtained from the local

settings. It is therefore safe to conclude that the ICT framework will be tailored to solve the problems in the public healthcare sector in Malawi although some components were still similar with other existing frameworks.

ICT Framework is locally validated

After the conceptual framework was developed, it was therefore locally validated by various experts so as to ascertain its relevance and applicability. Review experts were drawn from various disciplines in Malawi such as academicians, health professionals, policy makers, and health applications developers. The review experts were sourced from Malawi because it is expected that they are aware of Malawi's public health infrastructure.

Targeting a specific user

Most health applications developed so far are being used by healthcare providers to manage electronic medical records of the patients. They usually assist to make the work of healthcare providers easier. However, the target of the patient-centric ICT framework is the healthcare consumer who must be empowered with health information to help them manage their own health. With a patient at the centre of the healthcare system, the ICT framework facilitates the collaboration of many stakeholders including health applications developers, healthcare providers, and policy makers.

Technological solution within the local context

This ICT framework endeavours to provide an ICT solution to the delivery of patient-centric healthcare services. There is evidence that ICT has accelerated adoption of patient-centric approach in the public healthcare sector. The integration of EMRs, EHRs, and PHRs has increased the availability and access of health information among healthcare providers and healthcare consumers. The roll out of DHIS to all districts in Malawi, prompted the need for an integrated framework to monitor and evaluate the effectiveness, efficiency, sustainability, and scalability of ICT interventions in the public health sector. Additionally, dynamic advances in artificial intelligence, fog computing and internet of things (IoT), are expected to revolutionise the healthcare industry locally and globally, thereby making it more patient-centric.

Multidisciplinary approach

The ICT framework was developed from multidisciplinary perspective including information and communication technology (ICT), health informatics, nursing, and governance. It is expected that the multidisciplinary approach will be beneficial to both patients and healthcare professionals. This would enhance efficient resource utilisation for the healthcare provider and improved health outcomes for the patients.

Descriptive and not prescriptive approach

The framework focuses on providing the solutions to the problems within the context of the study, without specifying how it will be implemented. The advantage of this approach

is that the framework can be deployed differently in any similar settings. This ensures that the ICT framework is adaptable and scalable.

Holistic approach in local context

The ICT framework also took a holistic approach to focus on how the whole person interacts with their environment rather just focusing on their illness. The five areas considered are physical, emotional, social, spiritual, and intellectual. For a person to be healthy, there must be a good balance of these factors including physical exercise, maintaining a positive attitude, socializing with others, and spiritually enhancing oneself. The ICT framework needs to facilitate these aspects of health and well-being.

Artificial ignorance

This approach takes an advantage of analyzing outliers or unusual events in a particular system. During the course of developing the ICT framework, unusual responses by interviewees were considered and were further analyzed to determine if they had any significance in the delivery of healthcare services.

Conclusion

The findings from the semi-structured interviews were integrated with those from the literature review to reveal a number of challenges underlying ICT interventions in the health sector in developing countries, such as Malawi. Most participants reported that they were concerned with the inadequate financial funding for the public health sector. Poor funding ultimately leads to inadequate ICT infrastructure. Lack of strategies to sustain eHealth and mobile health systems compromise the delivery of quality healthcare systems. As a result, most healthcare consumers and healthcare providers therefore do not effectively benefit from the ICT interventions since some systems are not scalable.

A number of participants therefore suggested implementing an ICT framework which will be used as a guide to coordinate ICT interventions in the public health sector. This framework can be used by various stakeholders, such as policy makers, decision makers, health professionals, ICT developers, and others when devising and implementing ICT interventions. It is envisaged that the framework will ensure that such interventions are used cost effectively by both healthcare providers and healthcare consumers. This will consequently make the provision of healthcare services in the public sector more patient-centric. It is soothing to that note that ICTs have proven to play a pivotal role in making sure that healthcare services are more patient-centric. A number of participants therefore suggested some ICT related factors that may improve the patient-centricity in the public healthcare sector. One example of such ICT related factors is the availability of usable and useful mHealth and eHealth systems.

Data from the semi-structured and comprehensive literature study were used as input for the formulation of the framework. The development of the framework was also based on the principles of patient-centric models, design science paradigm, and user-centred design

processes. The following were the components for the proposed framework as gleaned from the participants and literature review: contextual framework; legal framework; health applications; patient-centric services; monitoring and evaluation; and involvement of stakeholders.

The framework was further validated by experts to ensure its validity and relevance. The experts unanimously agreed that the framework is relevant, useful, and applicable within the setting of Malawi. The framework can be also applied in any context with similar characteristics in the world.

In conclusion, the study has proposed an ICT Framework for supporting patient-centric healthcare services in the public health sector in Malawi. The challenges underlying the ICT development in healthcare systems have been considered. It was highlighted that social, economic, legal frameworks are vital for mHealth and eHealth applications to provide patient-centric healthcare services. Health systems need to be useful and usable focusing on the needs of the users. ICTs can indeed play a role to sustain patient-centric health applications. As a curative and preventive healthcare approach, a patient-centric healthcare approach empowers a patient to take responsibility of their own health and wellbeing. This ICT framework can be customized so that it is redeployed in other developing countries with similar environments in the world.

The adoption of a patient-centric healthcare approach can not only enhance satisfaction but also enhance a patient's experience while utilising healthcare services cost effectively. Empowering patients with health information encourage them to take full control of their own health and wellbeing. Patient empowerment can be augmented by good collaboration among healthcare providers and healthcare consumers. These key health players should have a conducive environment to share vital information over ICT infrastructure. By empowering patients, family members and friends with health information, caring for patients at home becomes easy, thereby reducing hospital congestion and expenses. This curative and preventive patient-centric approach therefore improves the efficiency in the delivery of healthcare services leading to patient satisfaction and better patient experience.

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Appendix 1: Profile of participants for semi-structured interviews

No	Designation	Organisation	Highest qualification	Experience (yrs.)
1	Product Manager	Baobab trust, Lilongwe	PhD in Health Informatics	6
2	Deputy Director	Ministry of Health, Lilongwe	Master's in public health	15
3	Associate Professor	Chancellor college, Zomba	PhD in Health Informatics	25
4	Deputy Director (ICT)	Ministry of Health, Lilongwe	Bachelor of Science, Computer Science	20
5	Senior Systems Administrator	College of Medicine, Blantyre	Master of Science in Health Informatics	8
6	Chief Systems Analyst	Department of E-Government, Lilongwe	Bachelor of Science in Computer Science	9
7	Chief Systems Analyst	Department of E-Government, Lilongwe	Master of Science. In Information Telecommunication Technology	30
8	ICT consultant	Business and Management Systems, Blantyre	Master of Science in Computer Science	24
9	Deputy Director of legal services	The Malawi Communications Regulatory Authority, Blantyre	Bachelor's in law	9
10	Health Informatics Technical Assistant	Ministry of Health, Lilongwe	Master of Science in health Informatics	15
11	Systems Developer Team Lead	Saint Luke, Mzuzu	Master of Science in health Informatics	9
12	Health Information Management Officer	Machinga District Hospital, Machinga	Diploma in Information and Communication Technology	4
13	Statistical Clerk	Machinga District Hospital, Machinga	Malawi School Certificate of Education	4
14	Health Information Management Officer	Zomba Central Hospital, Zomba	Advanced Diploma in Information and Communication Technology	6
15	Statistical Clerk	Zomba Central Hospital, Zomba	Malawi School Certificate of Education	5
16	Director of ICT services	Mzuzu University, Mzuzu	Master of Science in Information Theory, Coding and Cryptography	13

Appendix 2: Sample of questions during semi-structured interviews

Section A: Personal Information

1. Please introduce yourself by providing your full name, your designation or position in your organisation, name of your organisation, number of years of experience, and your highest academic qualification

Section B : Challenges underlying ICT development in public health care in Malawi

This section seeks to determine the challenges underlying the ICT development in public healthcare in Malawi.

- 1) what are the challenges or barriers or problems underlying healthcare ICT development in the public health sector ?
- 2) What are the possible solutions to the aforementioned challenges?

Section C: EHealth and m-health applications in Malawi

EHealth is the use of ICT tools such as computers, mobile phones, communications satellite, and patient monitors for providing health services and information. Mobile health is the use of mobile devices such as mobile phones to provide health services. Therefore m-health is a subset of eHealth.

- 3) Outline m-health and e-health applications that are being used in Malawi, of any?
- 4) From both the perspective of ICT consumer and ICT service provider, what do you think are the challenges that are encountered in providing mobile health and electronic health services in Malawi?
- 5) What are the possible solutions you can suggest to resolve the challenges that hamper the provision of ICT services in the healthcare public sector?

Section D: Patient-centric care in Malawi

Patient-centric care places more emphasis on the patient than the illness itself. It is a dynamic process through which the patient regulates the flow of information to and from him/her via multiple pathways to exercise choices consistent with his/her preferences, values, and beliefs. The proliferation of ICTs has increased the access and sharing of health information among patients, families, and health providers.

- 6) What ICT related factors or ICT enablers can enhance patient-centric care in Malawi?

Section E: Components of an ICT framework that can support a patient-centric approach in Malawi

There is a lack of an ICT Framework that can support patient-centric healthcare services in Malawi.

- 7) What do you think are the requirements or the components of an ICT framework that can support patient-centric healthcare services in Malawi?
- 8) What do you think are the benefits of implementing ICT framework that can support patient-centric approach in Malawi?

Appendix 3: Profile of participants of validation Reviewer (R)

	R1	R2	R3	R4	R5
Gender	Male	Female	Female	Female	Female
Designation/ Occupation	Head of Computer Science/ Academician, Software developer	IT Manager	Registered Nurse	Nurse	Nurse
Range of years of experience	11-15 years	Over 21 years	3-5 years	6-10 years	Over 21 years
Highest qualification	PhD	Masters	Bachelors	Bachelors	Masters
Location	University of Malawi, Chancellor College, Zomba, Malawi	Malawi Digital Broadcast Network. Lilongwe , Malawi	Lilongwe, Kamuzu Central Hospital, Malawi	Queen Elizabeth Central Hospital, Blantyre	Queen Elizabeth Central Hospital, Blantyre