Deciphering Barriers and Facilitators of eHealth Adoption in Uganda Using the Systems Thinking Approach - A Systematic Review

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Abstract. Several studies have explored the barriers and facilitators of eHealth adoption in Uganda but hardly any literature investigating these factors using a Systems Thinking perspective, which is the purpose of this study. A search for articles was done in several databases and only 35 articles were fit for the study. Five group model-building sessions were conducted to synthesize the data. As a result, six causal loop diagrams were constructed to provide a theoretical insight of the causation between the different factors. The study revealed that training users in Information and Communication Technology (ICT) improves their digital literacy and general awareness about ICT, which improves their knowledge of telemedicine and subsequently changes their attitude towards the use of eHealth systems. The eHealth trajectory in Uganda is still in its infancy hence, it is imperative for key players in the sector to painstakingly consider the contextual barriers of eHealth and capitalize on the facilitators if eHealth ensue.

Keywords: Barriers · Facilitators · eHealth Adoption · Systems Thinking

1 Introduction

eHealth is the use of Information and Communication Technology (ICT) in health products, services, and processes combined with organizational change in health-care systems and new skills, in order to improve health of citizens, efficiency and productivity in health-care delivery, and the economic and social value of health [1]. eHealth covers the interaction between patients and health-service providers, institution-to-institution transmission of data, or peer-to-peer communication between patients and/or health professionals [1]. in other words, ehealth primarily involves changing processes in health care using ICT.

In Uganda, eHealth has tremendously grown which is largely attributed by the exponential growth of the ICT sector. eHealth has moved tremendous heights in Uganda, for instance, in 2018, an application commonly known as an Antenatal Care Studio was developed to help pregnant women enhance their routine antenatal care decision-making practices [2]. WinSenga was an application developed by Makerere university students to detect problems such as ectopic pregnancy or abnormal fetal heartbeats [3, 4].

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Text-to-change, an SMS based platform was aimed at sending text messages to remind expectant mothers to go for antenatal care [5]. Similarly, in 2011, Ministry of Health rolled out the District Health Management Information System (DHIS2), which is currently serving more than 110 districts in Uganda. This system is aimed at providing a comprehensive data management solution to support reporting and analysis at different levels of the public health system [6], and is currently being used in over 40 countries in Africa, Asia and Latin America. Also, different mHealth projects have been successfully implemented in Uganda, for instance, ICT4Mpower, RapidSMS, Wise Pill, Health in Hand, Results SMS, Question box, mobile microscopy for automated malaria, community health worker data management [7]. Furthermore, projects like frontline SMS medic, eMOCHA, SURE, eHMIS, google SMS, freedom HIV/AIDS and OpenXdata have been implemented in Uganda.

The target beneficiaries of these mHealth systems include but not limited to; village health teams/community health workers, district health officers, health workers, patients, children, pregnant women, researchers and the general public. These mHealth projects have been implemented in majorly 27 districts of Uganda, for example, Bududa, Iganga and Tororo in the east; Kabwohe, Mbarara and Kabale in the west; Masaka, Kampala, Rakai in the central and Pader, Kitgum and Apac in the north.

The Government of Uganda acknowledges the potential of eHealth and as such, Ministry of Health of Uganda developed an eHealth strategy and framework, coupled to establishing a technical working group that meets regularly to guide this work [8]. Additionally, the national data transmission backbone and e-Government infrastructure project (NBI/EGI) connects Uganda to neighboring countries and links major towns, cities and government ministries and departments, with 48 government departments and six universities currently connected [9].

eHealth is one of the fastest growing sectors in healthcare industry and can be used at the local, national, regional and global levels as a resourceful means to promote and strengthen health systems and health information [10, 11]. eHealth has the potential to reduce overall costs by eliminating redundancy of diagnostic testing, travel expenses accumulated by rural patients travelling to urban hospitals, and reducing emergency cases by promoting regular checkups [12]. Furthermore, once adopted on a large scale, eHealth has a potential of accumulating useful data for medical research, follow-up on clients and contributing towards financial planning for healthcare [13, 14]. Once fully integrated in healthcare processes, these systems can greatly improve health service delivery.

While the potential of eHealth for Sub-Saharan Africa is great, its uptake is still very poor [9]. In Uganda specifically, several factors have contributed to the low adoption. These include: lack of ownership, limited content of health issues in local content, lack of support and funding [15]. Relatedly, the shortage of health professionals, unstable power supply, poverty, high telecommunication costs and the lack of government will exacerbate the situation [9]. A number of mHealth applications have been developed, often resulting in a complex web of overlapping services [2]. As a result, these systems have not been utilized to their full potential because of the fragmentation, providing both similar and different functionality across geographical regions, health services, levels within the health system as well as the continuum of care [16, 17].

To the best of our knowledge, the available literature does not discuss barriers and facilitators of eHealth adoption in Uganda using the Systems Thinking perspective, yet this approach elucidates the systemic behaviour of key processes within an ecosystem. The potential of system's thinking has been underscored in many studies such as understanding the geopolitical tension in Middle East [18], road accident prevention [19], modeling interactions among the sustainable development goals [20, 21], economy and production [22] and product development in software startups [23]. This potential compelled us to undertake this research in order to understand the barriers and facilitators of eHealth adoption from the system's thinking angle. This helped in appreciating the systemic consequences associated with the dynamics of operating in a complex environment specifically the health sector. Similarly, this study demonstrated the contextual factors and their relationship in influencing health system's use, which is paramount to consider before systems are implemented.

The paper has been structured in the following ways, a) methodology, which involves the review of literature on barriers and facilitators of eHealth, a synthesis of the review findings, presenting findings using causal loop diagrams (CLD), and validating the CLD's, and b) discussion of findings. The paper concludes by suggesting interventions and directions for future research.

2 Methods and Materials

2.1 Study Setting

This study employed the research design in Fig. 1, which drew from existing studies [24] describing systematic reviews anchored in the line of systems thinking to understand a system as a whole while discerning leverage points to institute change.

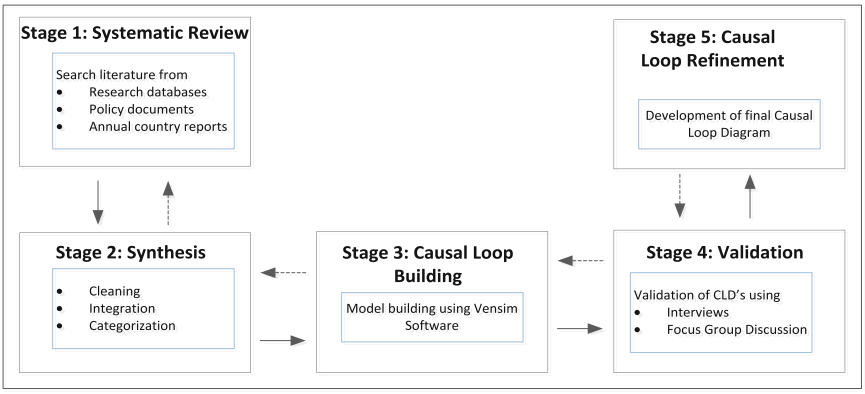

Fig. 1. Research Design Framework for Systematic Reviews in Systems Thinking

Stage 1: Systematic Review

Article selection process

Searches from the bibliographic databases yielded 345 articles and internet searches of grey literature yielded 26 resources as demonstrated in Fig. 2. Two hundred seventeen papers of the 345 articles were duplicates, hence excluded. Of the 154 bibliographic and grey literature searches, 79 articles were relevant to eHealth adoption after a thorough screening of the abstract and title. After a full text review, 35 articles that fit the inclusion criteria and demonstrated relevance to the research purpose were selected. Majority of the articles were published in 2019 as demonstrated in Fig. 3. The authors and a team of six research assistants conducted the article search.

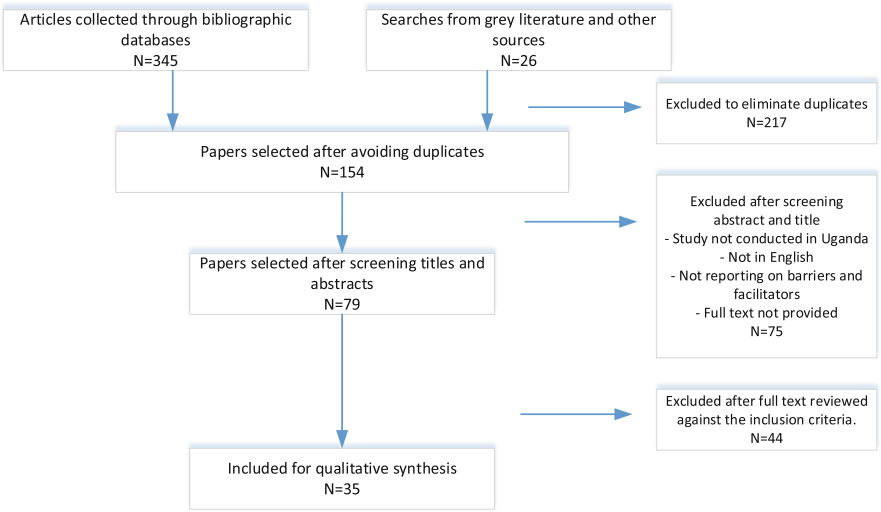

Fig. 2. Flow Chart Summarizing the Process of Selecting Published Literature

A systematic search for peer-reviewed articles on the barriers and facilitators of eHealth adoption in Uganda was conducted from June to December 2020. A search was done in PubMed, which included the following terms: ((“Uganda” [MeSH] AND “ehealth” [All fields] OR “mHealth” [All fields] OR “telemedicine” [MeSH] OR “telemedicine” [All fields] OR “telehealth” [All fields] OR “electronic health records” [MeSH] OR “electronic health records” [All fields] OR “electronic medical records” [All fields] OR “digital health records” [All fields]) AND (“barriers” [All fields] OR “facilitators” [All fields]) AND (“adoption” [All fields] OR “adoption” [MeSH]) OR (“systems” [All fields] AND “dynamics” [All fields] OR “systems dynamics” [All fields] OR “systems” [All fields] AND “thinking” [All fields] OR “systems thinking’ [All fields]) OR “uptake” [All fields] OR “factors” [All fields]). Similar searches for grey literature, including theses, government reports, conference proceedings, websites was conducted in google and google scholar using the following search terms; eHealth adoption in Uganda, uptake of eHealth in Uganda, telemedicine in Uganda, barriers of eHealth in Uganda, facilitators of eHealth in Uganda, Systems Thinking in eHealth. Others searches

were made in African journals Online, Springer, Emerald Publishers, ScienceDirect, Taylor and Francis, Embase, Medline, Cochrane library. Some articles were obtained from the reference list of the selected articles while others were references from colleagues.

Selection criteria included; i) studies conducted in Uganda, ii) literature searches (systematic reviews or meta-analyses), iii) qualitative, quantitative and mixed method studies, iv) articles published in English whose full text were accessible, v) studies focusing on barriers and/or facilitators of eHealth or telemedicine or electronic health records or mhealth. The exclusion criteria included, eHealth articles not reporting on barriers or facilitators of eHealth, articles whose full text was not accessible.

The authors along with four research assistants reviewed the selected articles independently to avoid bias and consensus was reached after a thorough scrutiny of these independent reviews by the group. For consistency, the individual reviews were cross-referenced against each other using a 3-item checklist drafted by the authors. This checklist included; the publication author and year, barriers and facilitators.

Table 1 and Table 2 below summarize the final Barriers and facilitators of eHealth Adoption compiled from the selected articles.

Stage 2: Synthesis

The rationale for conducting this review was to understand the barriers and facilitators of eHealth adoption in Uganda and generate new insights that could inform key players involved in the implementation of eHealth technologies. Using the Systems Thinking approach that provides a framework for viewing a system holistically and establishing relationships and patterns, the objective of this phase was two-folds; i) identify and compare findings in order to compile a list of common and dissimilar concepts, and ii) use these concepts to create themes to guide the construction of Systems Thinking models.

The results in table 1 were shared among four RA's and the lead research (HKN) to acclimatize with the findings. The researchers' role at this phase was to identify sections in the reviewed literature that had common threads associated to potential barriers or facilitators to eHealth adoption. Each researcher reviewed and coded the findings independently. During this process, common patterns were coded and gaps in the existing research were identified, which provided a basis to reinforce our interventions. The six researchers independently validated all the coded data, however, to minimize bias, researchers were required to validate each other's findings. At this point of data extraction and codification, common concepts were collapsed together and ambiguous ones demystified. Researchers then converged to thematize the data, however, researchers' codes were compared to establish any similarities and differences, and later build consensus. A clustered approach to theme generation and analysis was employed, which involved grouping barriers or facilitators in groups of ten, and then each factor within a group carefully studied to ascertain its appropriateness in a defined theme.

This synthesis generated six main themes. The themes were reviewed by the authors independently to ensure that all concepts fit within a theme and no data was left out. All themes were synthesized to facilitate the construction of Systems Thinking models to generate theoretical insights into the data, provide an explanation into the slow adoption of eHealth in Uganda, and draw possible interventions. Both the coded data and the generated themes were given to four independent researchers (not part of the study) to

Table 1. Facilitators of eHealth Adoption

Authors and Year	Facilitators
Ministry of Health, 2016	Proper policy planning, relevance to local environment, harmonization of current initiatives. Stakeholder engagement, effective policy and governance models. Deployment in phases, conform to eHealth Enterprise Architecture and interoperability. Secure network infrastructure, change management. National oversight, integrating local innovation. Leverage existing investments, branding and awareness, skills development, training
Omaswa, 2013	Government leadership, confidentiality, security, leverage existing eHealth initiatives, development of eHealth programmes that improve outcomes. Public, private collaboration, user-friendly systems. Capacity building, investment in eHealth, access to eHealth services. Utilization of eHealth information, quality and integrity of eHealth information. Awareness for eHealth, change of work practices, implementation of appropriate laws, effective policies. Access to communication services, provision of functional computing infrastructure, provision of technical services, continuous monitoring
PEPFAR, 2019	Integrated system from community to national level health system, eHealth EA framework, usefulness, capacity building (local community)
USAID, EPFAR and AIDS free, 2019	System usefulness, perceived improvement in health outcomes, meet patient needs. Improved turn-around time and community engagement
Mwagale & Kakaire, 2010	Scalability, implementation in existing CHW's program, network coverage and trust. Collaborations with organizations, real-time data reporting. Web-based and open source systems for multiple users. Multimedia messages, buy-in from users, ease of use. Training, use of local staff, technical skill to install and configure
Muhaise, et al., 2019	Stakeholder involvement, dedicated users, good change management strategy, effective leadership, effective communication, training staff, time management, evaluation of organizational needs. Better health outcomes, efficiency, emerging payment methods, error reduction, institutional pressure and competition, staff support, quality patient follow up, perceived ease of use, perceived usefulness. Quality of health services information exchange
Kiberu et al., 2017	eHealth readiness assessment, right policies. The evolution smartphone, proper physical infrastructure, technology equipment, user and managers' skills. Adequate planning, ehealth strategy, ease of use and transfer of skills. Legal and ethical policy, clear best practice guidelines

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Table 1. (*continued*)

Authors and Year	Facilitators
Kiberu et al., 2019a	Organization readiness, investing in ICT infrastructure. Technologically appropriate, culturally sensitive and locally relevant, health provider readiness. Usefulness, resource and information availability, security, current level of ICT use, training. Integration with current workflow processes, organizational support
Kiberu et al., 2019b	Local buy-in, ICT availability, ICT affordability, quality of ICT infrastructure, use of networks, availability of ICT technical support. Willingness to use ICT, introduction of 3G/4G networks
Kiberu et al., 2019c	Community's ability to implement, available capacity, perceived usefulness. ICT infrastructure, collaboration between partners, skilled eHealth and IT resources
Yagos et al., 2017	Willingness to invest in ICT, create ICT awareness, train health workers to use ICT in health service delivery
Wandera et al., 2019	User-friendly software, web-based and integrated reporting and availability of computers. Training staff, supportive supervision and performance review meetings. Motivation, competence of staff. Collaborative networks
Wandera et al., 2018	User-friendly interfaces, co-design, availability of technology devices. Training on HMIS, adequate funding, routine performance reviews, compliance enforcement, teamwork among users, supportive supervision. Integrated reporting system, stakeholder engagement and collaboration. Positive attitude, ICT competence, motivated users
Isabalija et al., 2011	Tailoring systems with existing success stories, contextual consideration and sustainability. Sensitizing staff, equip staff skills, availability of computing resources, streamline telemedicine policies. Government support, public-private partnerships, reduction on telecom costs, formulate laws to guide telemedicine practitioners, security and confidentiality laws to secure patient data
Cargo et al., 2015	Existence of e-laws, collaborating with stakeholders, mobile financial services specifically mobile payment
Meyer et al., 2020	Knowledge and beliefs, self-efficacy, individual stage of change, individual identification with organization. Planning, stakeholder engagement, executing. Structural characteristics, networks and communications, culture, tension of change, compatibility, relative priority, organizational incentives, goals and feedback, learning climate. Leadership, engagement, available resources, access to knowledge. Patient needs and resources, cosmopolitanism, peer pressure, external policies and incentives. Evidence strength and quality, intervention source, relative advantage, adaptability, trialability, complexity, design quality and cost

(*continued*)

Table 1. (*continued*)

Authors and Year	Facilitators
Kabukye et al., 2020	Vision clarity, change appropriateness, presence of champions, flexibility, change efficacy and collective efficacy. Training, strategic implementation process, IT infrastructure, perceived benefits
Ayiasi et al., 2015	Linkage between the VHT and mothers, professional advice from health workers. Trust and confidence, assorted services, perception by women, ease of getting information, positive care
Huang et al., 2017	Political, social, historical contexts, perception, stakeholder needs, attitude, interoperable systems. Training, usefulness, ability and willingness of the users, supervising users, support. Change management, identifying champions, adopting an incremental approach
Baryashaba et al., 2019	Improvement in job performance, ease of use, support from management, availability of technical infrastructures. User involvement, structured approach of requirements elicitation, local champion, capturing local context, system's ability to act as diagnosis assistant, retrieval of patients' historical data, Communication, training, perceived job simplification
Campbell et al., 2017	SMS message language, phone characteristics, technology literacy. Confidentiality, usability training, system's ability to improve linkage and quality of clinical care, system facilitates social support, patient-centred care
Boatin et al., 2015	Commitment, local champion, real-time interaction, evaluation of the program
Chang et al., 2011	Synergy between service providers and consumers, stakeholders support
Chang et al., 2013	Synergy between users, perceived usefulness, easy to use, multimedia capability, sensitizing the masses, intervention acceptability
Angues et al., 2018	Supportive supervision, skills training, mhealth awareness, acceptability of the innovation, integration in existing workflows, system usefulness, constant monitoring, prior knowledge in using ICT's
DeStigter, 2012	Simple interfaces, supervised training, robust community education, integrated service delivery with existing programs
Isabalija et al., 2013	ICT infrastructure, support from a national healthcare system. Strong partnerships, capacity building, sustainability, collaborative policy. Leadership competence, effective collaboration, understanding the community, funding, staff involvement and program responsivity. Knowledge management practices, donor involvement, technology transfer project environment

(*continued*)

Table 1. (*continued*)

Authors and Year	Facilitators
Konduri et al., 2012	Multi-stakeholder partnership, well-defined research agenda, build systems for triangulation, geo-mapping. Ensure user acceptance, ownership, culture of data use, human resource capacity. Transparency, accountability, governance frameworks
Larocca et al., 2016	Strengthen community engagement, encourage a multidisciplinary approach, human resource investment, financial investment, technology infrastructure, training users
Martin et al., 2020	Easy to use, perception of usefulness, presenting information in multiple formats, acceptability of the system, training, user involvement, device maintenance
Ggita et al., 2018	Tailor design, monitoring, acceptability of the system, presenting information in multiple formats, confidentiality, personalization of mHealth intervention
Okunade et al., 2019	Stakeholder preferences, security, mapping information and data needs, piloting of the systems, evaluation of the system, patient-focused intervention, communication and integration of services
Olok et al., 2015	Level of ICT skill, level of ICT use, attitude, acceptability, usefulness, compatibility, usability, trialability and access to ICT
Roberts et al., 2015	Acceptability, presenting information in multiple formats, access to technology, integration of mHealth initiatives in daily activities, stakeholder involvement

ascertain the validity of the findings. Feedback from the independent researchers was scrutinized and the authors unanimously agreed to consider it to improve the themes.

The six generated themes included; awareness, access, external, individual, organizational and technological factors. Table 3 below shows the number of studies by theme.

From the synthesis, it was revealed that all studies reported either barriers, facilitators or both as seen in table 3. The categorization of these factors into themes saw organizational and technological factors as the major contributors of eHealth adoption in Uganda (see Fig. 4).

Stage 3: Causal Loop Building

A *causal loop* is a circular chain of variables affecting one another in turn [25]. One variable affects a second variable, which in turn affects a third variable, and the third variable then affects the first [25]. The causal loop diagrams depict the feedback mechanism, concepts and relationships of the real system. The arrows between variables (causal links) denote causal influences [26]. The polarity ' + ' or ' − ' of each causal link indicates a positive or negative relation between the variables [26]. A positive polarity means that two variables change in the same direction i.e. if the variable in which the

Table 2. Barriers of eHealth Adoption

Authors and Year	Barriers
Ministry of Health, 2016	Lack of ownership, limited local content, lack of support, lack of funding, lack of a sustainability plan, lack of skilled HR
Mwagale & Kakaire, 2010	Battery life, signal transmission, intentional non-use, lack of an SMS cost estimator, lack of a sustainability plan, access to accurate data. Lack of eHealth policies, lack of local capacity, translation to local language. Technophobia, unreliable electricity, unavailability of local content, monopolizing the innovations and cost of Smartphone, procurement process. Scalability, poor network coverage, training CHW is hard, low education level, low turn up for training, no trust. Lack of local ownership, costs of implementation and maintenance
Muhaise, et al., 2019	Attitude, costs, culture, improper implementation, improper planning, inadequate training and skills, interoperability issues, lack of time, lack of expert support, organizational barriers, political influence, power supply, resistance, risks, security, staff retention, technophobia, understaffing
Kiberu et al., 2017	Silo systems, interoperability issues, pilot systems, donor funded, lack of sustainability and scalability plans. Lack of ownership and accountability, lack of support, funding, poor coordination, communication, no e-Health frameworks. Security of data. Lack of competence, no ethical guidelines. Power blackouts, internet connectivity and unskilled workforce. Network coverage, telecommunication infrastructure and illiterate community. Lack of knowledge, lack of medical specialist, limited support from ICT staff, resistance from users. Computer illiteracy, shortage of ICT personnel and inadequate infrastructure. Poor planning, change management, technology readiness
Kiberu et al., 2019a	Sustainability, silo systems, lack of awareness, lack of IT skills, infrastructure and organizational support
Kiberu et al., 2019b	Lack of readiness, insufficient technology resources, limited use of ICT resources, regular power blackouts. Limited IT professionals, telemedicine naivety, quality of service, equipment and budget for ICT, legal and regulatory issues, quality of care. Lack of ICT policy, inadequate ICT staff, lack of internet, lack of training
Kiberu et al., 2019c	
Yagos et al., 2017	Inadequate ICT knowledge and skill, poor internet, inadequate computers, inadequate power supply, lack of internet modems, access to computer centres
Namatovu & Oyana, 2021	Lack of ICT skills, limited knowledge, high costs of data services, poor internet, lack of integrated ICT services

(*continued*)

Table 2. (*continued*)

Authors and Year	Barriers
Wandera et al., 2019	Limited supply of computers, limited human resources, high levels of staff attrition, inadequate training, poor culture of information use, and frequent stock-outs and behavioral barriers
Wandera et al., 2018	Unfriendly software, technology issues, limited computers and poor maintenance. Shortage of human resources, limited training. Lack of technical support, personality and poor attitude. Lack of logistical support, data inaccuracy. Poor internet, unstable power supply, heavy workload
Isabalija et al., 2011	User resistance, lack of technical staff, lack of training, lack of computers, lack of policies. Lack of government support, lack of private sector support, high telecom costs, lack of e-laws, fear of sharing confidential data. Lack of knowledge, lack of resources in hospitals
Cargo et al., 2015	Literacy levels, cross-sector partnership, low smartphone penetration, strict tax regimes. Electricity issues, no smart phones, user-unfriendliness
Meyer et al., 2020	Shortage of ICT personnel, funding, logistics of implementation. Technological failures, lack of trust and complex data structures
Kabukye et al., 2020	Lack of computer skills, understaffing, organization conflicts, financial constraints, space for computers, inflexible government policies
Ayiasi et al., 2015	Irregular phone connectivity, absenteeism of health workers, health worker's workload. Limited electricity, no compensation
Huang et al., 2017	Limited internet, electricity supply. Poor motivation, transaction costs, limited expertise
Baryashaba et al., 2019	Having both a manual and automated system, limited skilled personnel, scarcity of computers, poor computer network, user resistance
Campbell et al., 2017	Limited battery life, poor network, illiteracy, no local languages, lack of airtime, phones, digital illiteracy, financial implications, inadequate staff
Boatin et al., 2015	Internet connectivity
Chang et al., 2011	Phone access, privacy concerns, phone maintenance, costs, electricity issues
Chang et al., 2013	Access to phones, confidentiality issues, security issues
Angues et al., 2018	Security, frequent power cuts, poor network, inconsistent connectivity, logistical and institutional problems. Charging issues, human resource

(*continued*)

Table 2. (*continued*)

Authors and Year	Barriers
DeStigter, 2012	Cost, electrical power requirements
Isabalija et al., 2013	Huge gap between supply and demand, distribution imbalance, poor quality of service, poor network, social dynamics like fear to reveal health condition
Larocca et al., 2016	Lack of alignment, integration of m-Health with existing health systems, ICT infrastructure bottleneck, limited Internet connectivity
Martin et al., 2020	Power problems
Okunade et al., 2019	Lack of evidence on the preferences of patients
Olok et al., 2015	Lack of knowledge, unreliable ICT equipment, high cost, low skills, technology compatibility, lack of ICT infrastructure. Access and reluctance to use eHealth
Roberts et al., 2015	Lack of ICT training, lack of mobile phones and lack of willingness,

link starts increases, the other variable in which the link ends will also increase. A negative polarity means that the linked variables change in the opposite directions i.e. if the variable in which the link starts increases, the other variable in which the link ends will decrease. The causal loops are either negative (balancing) or (positive) reinforcing. A negative (balancing) loop exists when a small increase (or decrease) of any variable in the loop results in a decrease (or increase) of the same variable [26]. Likewise, in positive (reinforcing) loop, a small increase (or decrease) of any variable in the loop results in an increase (or decrease) of the same variable [26]. Reinforcing loops can be either virtuous (desirable growth) or vicious (undesirable growth).

To come up with causal loop diagrams (CLD's), the researcher employed a group model building approach, which provided a structured process to engage the RA's. For each theme generated in stage 2, a connection circle was drawn to provide insight into the causal relationships between variables and identify feedback loops within the system. Two groups were created and presented with the variables of a particular theme. Each group was required to draw a connection circle for the theme, identify a relationship between any two variables, drawing causal links and indicating polarity. The two groups then converged to discuss their findings and ascertain that each group's connection circle is complete and that all relationships have been adequately represented. At this point, consensus was built and CLD's were drawn. The rationale of having two groups working on the same theme to draw the connection circle was, to a certain extent, intended to minimize bias and misrepresentation of loops, polarity and causal links.

Causal loop diagrams in Fig. 5, 6, 7, 8, 9 and 10 were built to visualize how different barriers and facilitators affect adoption of eHealth in Uganda and to establish a correlation of the identified variables as a way of creating new knowledge to inform decision-making. The model building was an iterative process done using Vensim modelling software.

Table 3. Thematization of barriers and facilitators according to studies

Themes	Factors	Facilitators (F): (No. of studies)	Barriers (B): (No. of studies)
Awareness	Training/Sensitization	26	7
Access	Access to accurate data	1	3
	Access to eHealth systems	6	0
	Network/internet coverage/quality of service	7	19
	Communication	8	1
External	Stakeholder involvement	17	0
Individual	Ownership	2	3
	Education level	2	4
	Trust	2	2
	Costs	2	8
	Acceptability of the system / willingness to use	12	6
	Knowledge / skill	5	6
	Attitude of users	9	9
	Technophobia	0	3
	Time	2	1
	Digital literacy	3	2
Organization	Support (organizational, healthcare provider)	20	11
	Funding	6	5
	Sustainability plan	2	4
	Local champion	6	0
	eHealth policies/standards	7	4
	Electricity/power blackouts	0	9
	Logistical issues	0	3
	Scalability	1	2
	Culture	5	2
	Planning	7	3
	Human resource	7	9
	Pilot system	1	1
	Readiness (technology, user, organizational)	11	2
	Deployment in phases	2	1

(*continued*)

Table 3. (*continued*)

Themes	Factors	Facilitators (F): (No. of studies)	Barriers (B): (No. of studies)
	Enterprise Architecture framework	2	0
	Quality of health service	6	1
	Trialability	2	0
	Change management	6	0
	Performance reviews	3	0
	Integration with current workflow processes	3	0
	Collaboration	7	0
Technological	Battery life	0	3
	Local content	3	4
	Maintenance of eHealth systems	3	4
	Interoperability	3	3
	Security/privacy/confidentiality	8	5
	Existence of ICT infrastructure/Access to phones	16	19
	Usefulness of the system/tailored design	19	5
	Presenting the system in multiple formats	14	0
	Ease of use	7	0
	Adaptability	1	0
	Technology compatibility	0	1

These CLD's were generated from the connection circles drawn in stage 2. A total of seven balancing and twenty-seven reinforcing loops were generated.

The causal loop diagram in Fig. 5 presents the awareness factors impeding eHealth adoption with three reinforcing virtuous loops (R1, R2, and R3).

Loop R1 is a virtuous cycle that shows growth in the digital literacy. Training ICT users increases their digital literacy, which in the end will reduce on the cost incurred in training since majority will have acquired the digital skills. Once the costs of training users decrease, the urge to train users will substantially increase. *Loop R2* is a virtuous cycle that demonstrates the growth of ICT awareness. When the user's awareness of ICT increases, their knowledge and appreciation of telemedicine increases as well and the reverse is true. Similarly, *Loop R3* is a virtuous loop, which demonstrates the increase of ICT awareness makes user's knowledge of the importance of telemedicine increase, which largely reduces on the cost of training since majority are knowledgeable of these

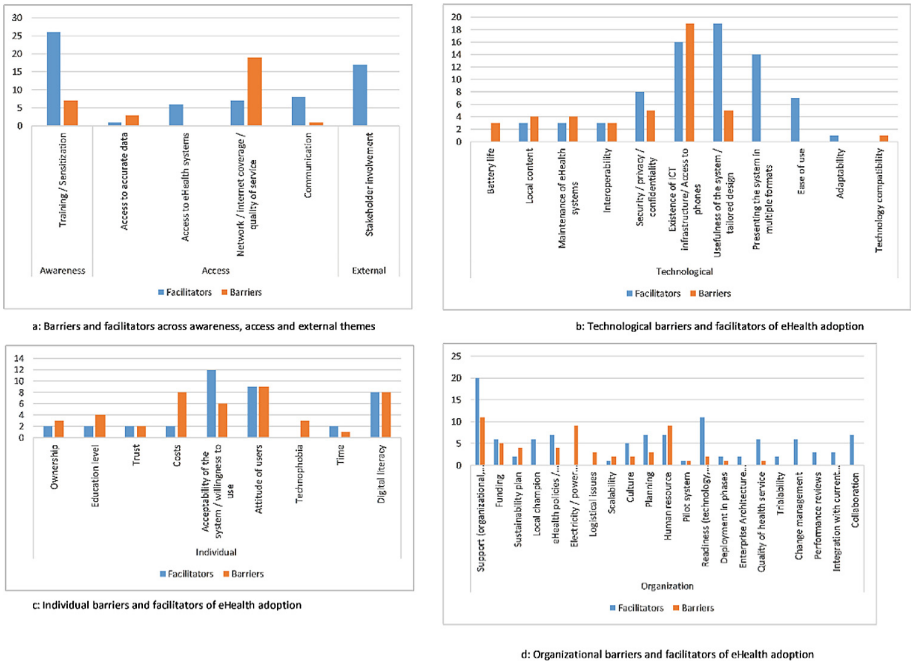

Fig. 3. Studies conducted on barriers and facilitators of eHealth adoption in Uganda

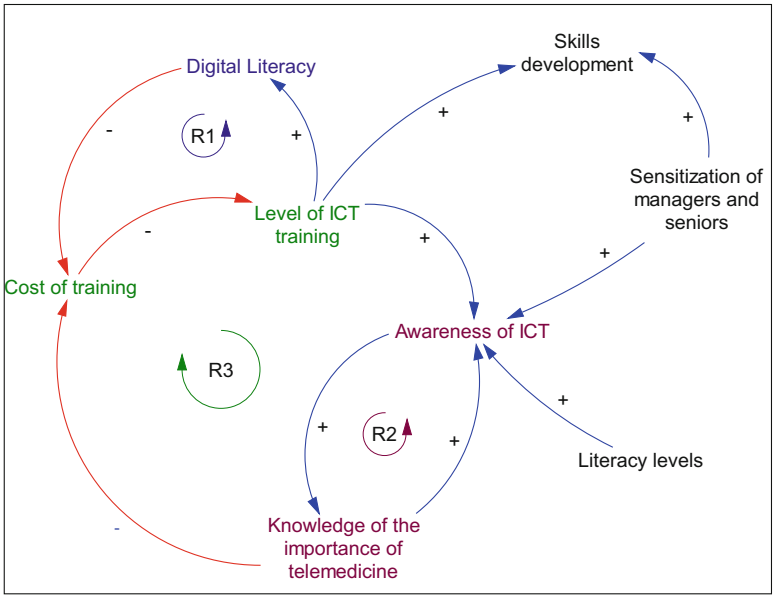

Fig. 4. Causal loop diagram of the awareness factors impeding eHealth Adoption

digital health systems. Reduction of the training costs has an uphill influence on training, which in the end, increases ICT awareness.

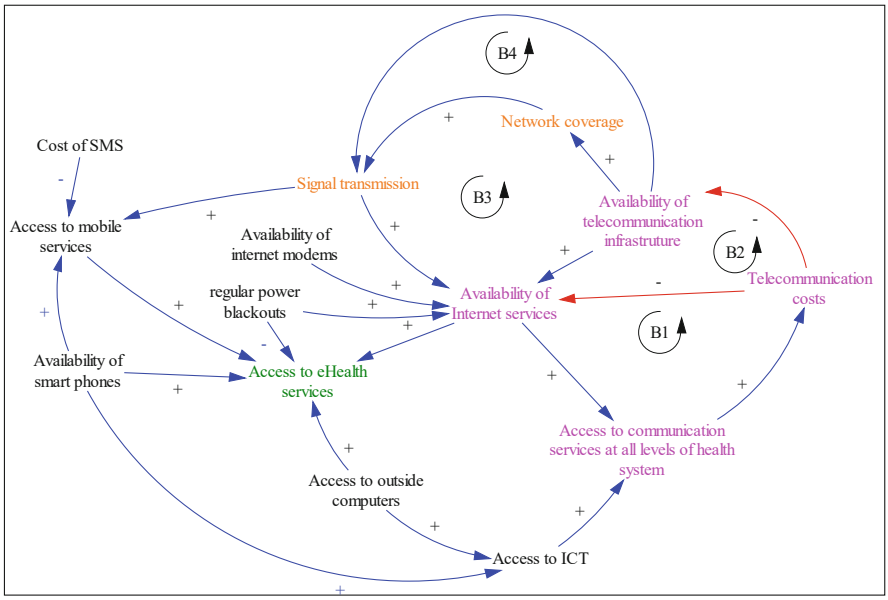

Fig. 5. Causal Loop Diagram for Access factors affecting eHealth Adoption

Figure 6 presents the access factors affecting eHealth adoption and has four balancing loops (B1, B2, B3 and B4).

Loop B1: Availability of internet services tantamount to increased access to communication services across all levels of the health system, which eventually leads to the increase in telecommunication costs. When the costs of telecommunication for example Internet subscription costs and installation costs increase, the demand for Internet services reduces. Likewise, (*in loop B2),* the increase in telecommunication costs reduces the availability of telecom infrastructure partly attributed to the few subscribers who may not afford the services. This reduces the demand for Internet services. Consequently (*in loop B4*), the availability of telecom infrastructure improves the signal transmission leading to improved Internet services, however, with increased access to communication, the telecommunication costs increase leading to decreased demand of Internet services. *Loop B3:* Availability of telecommunication infrastructure improves the network coverage, which in turn improves the signal transmission leading to improved availability of Internet services.

Figure 7 presents the external factors related to eHealth adoption and has three reinforcing loops (R4, R5 and R6). *Loop R4* demonstrates a virtuous cycle of increased implementation of eHealth policies and standards. The existence of eHealth policies, standards and systems enables the concerned stakeholders especially in the ministry to enforce national guidelines for security of eHealth information. Once the security of eHealth information has been observed, this, to a certain degree pushes the sectors

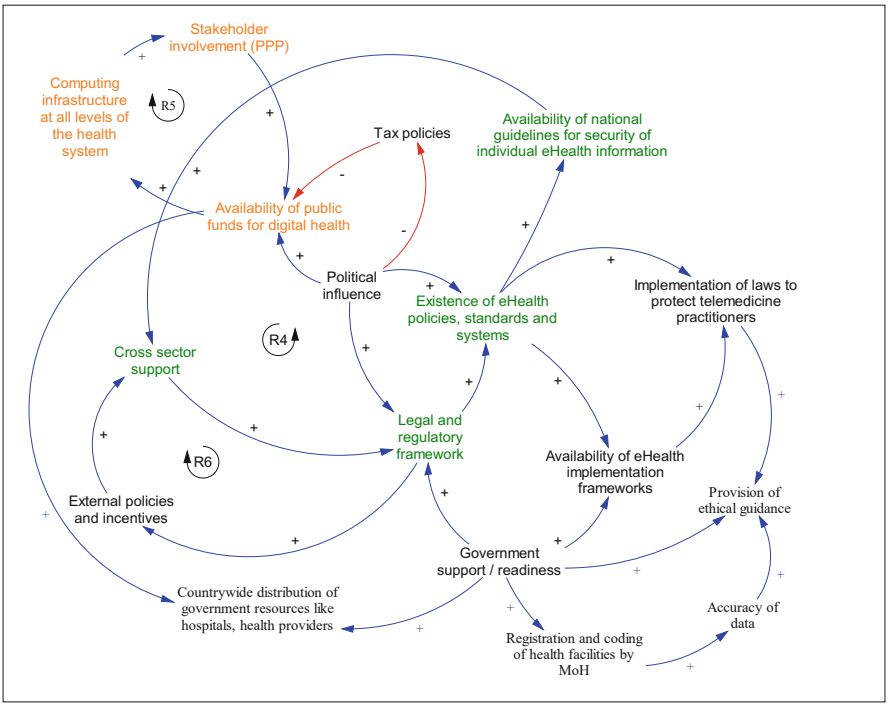

Fig. 6. Causal loop diagram demonstrating external factors to eHealth Adoption

within the health ecosystem such as civil society organizations and non-governmental organizations to advocate for eHealth adoption. Once this support has fully been galvanized, it will push for a proper legal and regulatory framework leading to enforcement of eHealth policies and standards. *Loop R5* is virtuous loop, which shows an increase in availability of funds increasing computing infrastructure at all levels of the health system, which increases stakeholder involvement, as many stakeholders would potentially want to capitalize on the available infrastructure. This substantially leads to an increase in availability of funds resulting from a pool of resources from different stakeholders. *Loop R6*: The implementation of the structured legal and regulatory framework leads to advocacy for external eHealth policies and incentives in support of eHealth, thus leading to a more conducive environment for cross-sectoral support. This further enhances the implementation of the structured legal and regulatory framework thus creating a virtuous cycle.

The causal loop diagram in Fig. 8 demonstrates the individual barriers to eHealth adoption with six reinforcing loops (R7, R8, R9, R10, R11, R12) and two balancing loops (B5, B6). *Loop R7* is a virtuous loop, which is desirable. The increase in trust reduces the fear to reveal personal health data, and as this fear reduces, there is increased trust to use eHealth systems. *Loop R8* demonstrates an increase in sharing confidential data leads to an increase in the fear to reveal health condition, and as the fear increases, there is a decrease in the sharing of confidential data. *In loop R9,* the increase in the fear to

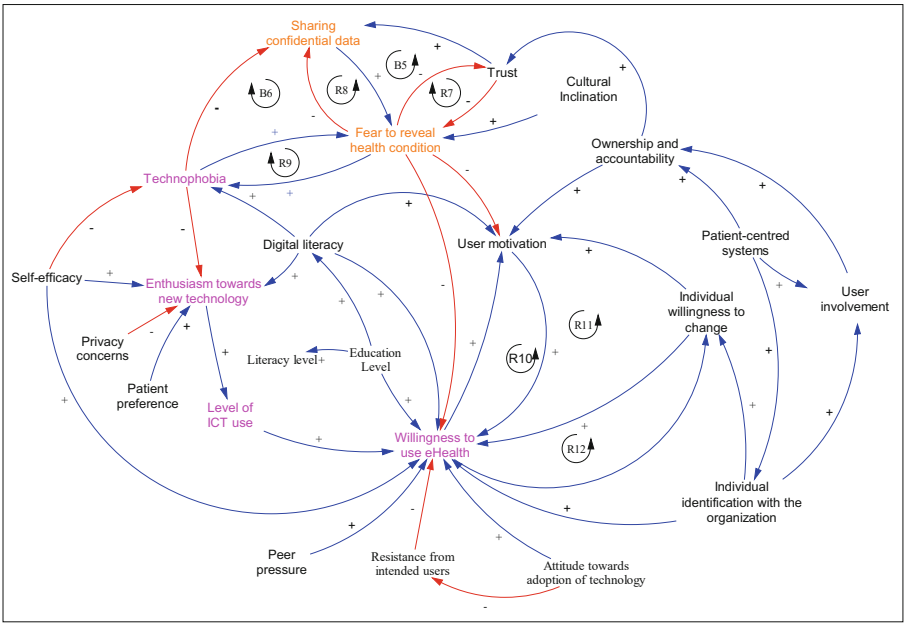

Fig. 7. Causal loop diagram demonstrating individual barriers to eHealth Adoption

reveal health condition increases technophobia. Likewise, the increase in technophobia leads to an increase in the fear to reveal health condition. *Loop R10* demonstrates an increase in user motivation leading to an increase in the willingness to use eHealth systems. Similarly, an increase in willingness leads to an increase in user motivation. *Loop R11* shows an increase in willingness to use health systems leads to an increase in the individual willingness to change leading to an increase in user motivation and willingness to use digital health technologies. *Loop 12*, as the will to use eHealth systems increases, it causes an increase in the willingness to change. Equally, an increase in the will to change reinforces the will to use digital health technologies. *In loop B5,* increase in trust, increases the confidence to share confidential data. As sharing confidential data increases, there is an increase in the fear to reveal health information, which decreases the trust. *In loop B6*, as sharing of confidential data increases, it increases the fear to reveal health condition, which subsequently leads to increase in technophobia. As technophobia increases, it reduces the sharing of data.

Figure 9 presents the organizational factors affecting eHealth adoption and has twelve reinforcing loops (R13, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23 and R24) and one balancing loop (B7). *Loop R13, R14 and R15* are virtuous reinforcing loops. In *Loop 13*, an increase in planning and coordination leads to an increase in the user's turn-up for training. When turn-up increases, user's competence to use eHealth systems increases, increasing their motivation to use. As the staff motivation increases, users avail time *(loop 13)*, there is an increase in technology readiness *(loop R14)* and an increase in organizational support *(loop 15).* When organizational support increases, there is increased planning and coordination. *Loop 16* demonstrates an increase in organizational

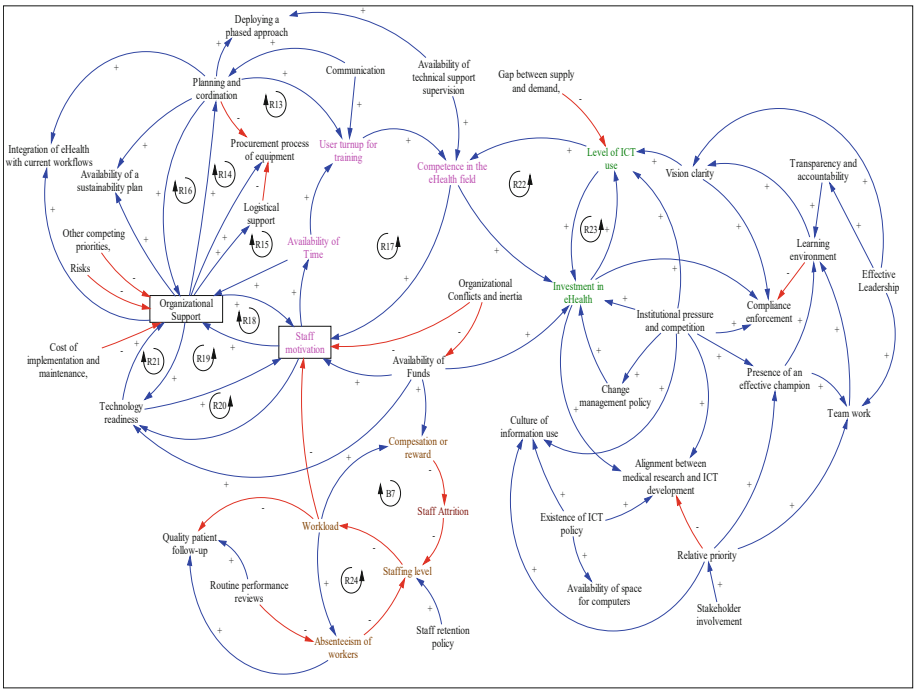

Fig. 8. Causal Loop Diagram of organizational factors affecting eHealth Adoption

support increases planning and coordination, and as planning and coordination increases, there is more support from the organization. *Loop R17 reinforces the morale to use eHealth technologies.* As the user's competence to use eHealth systems increases, the staff motivation to use technologies increases, which subsequently increases the time staff avail to learn and use eHealth systems. Once the time increases, user turn-up for training potentially increases which consequently increases their competence and skill to use digital health systems. *Loop 18* shows an increase in staff motivation leading to an increase in organizational support, and an increase in organizational support leads to an increase in staff motivation. In *loop 19,* an increase in organizational support leads to an increase in technology readiness within the organization, leading to an increase in staff motivation. When motivation increases, it leads to an increase in organizational support. *In loop 20,* an increase in technology readiness in an organization increases staff motivation, likewise, an increase in motivation increases technology readiness. *In loop 21,* an increase in organizational support increases technology readiness, and an increase in technology readiness leads to an increase in organizational support. In *loop 22*, increased competence in the eHealth field, leads to increased investment in eHealth systems, which increases the use of ICT. As ICT use increases, users become more competent to use health systems. Likewise*, in loop R23* an increase in the investment in eHealth increases ICT use and subsequently, the increase in the level of ICT use will force those concerned to invest in eHealth technologies. *Loop R24* is a vicious reinforcing loop. As workload increases, there will be an increase in abseentism of

workers, which reduces the staffing levels, leading to an increase in the workload. *In loop B7*, an increment in staff reward, will reduce staff attrition, which will increase the staffing levels as a result of reduced turnover. As the staffing levels increase, there will be a substantial reduction in the workload. As the workload reduces, it also reduces on the compensation and reward given to staff.

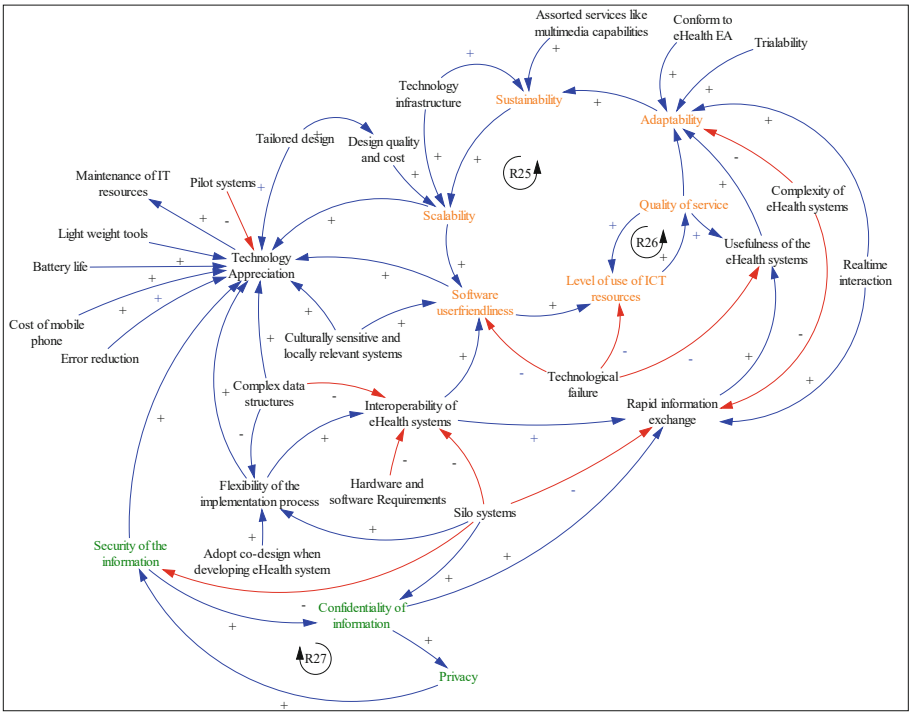

Fig. 9. Causal Loop Diagram for technological factors affecting eHealth Adoption

Figure 10 presents the technological factors affecting the adoption of eHealth with three reinforcing loops (R25, R26 and R27). *Loop R25*: The increase in the scalability of the system leads to an increase in user-friendliness. As systems become user-friendly, using ICT resources increases, leading to improved quality of service. As the quality of service increases, it increases the user's adaptability to eHealth systems, which pushes organizations to increase the sustainability of these systems. The more sustainable the system is, the more likely it is to scale it. *Loop 26:* The increase in the level of ICT use leads to an increase in the quality of service. As the quality of service increases, it increases the use of ICT's. *Loop R27*: The increase in confidentiality of information will

lead to an increase in privacy, which subsequently leads to improved security of personal health data.

Stage 4: Validation
Validation of the CLD's was a two-tier process conducted by, i) subject matter experts abreast with system thinking knowledge, and ii) experts from Ministry of Health and researchers in the field of eHealth specifically from the School of Public Health and School of Computing and Informatics Technology at Makerere University. A total of 8 academic staff and 6 SME's completed the validation process. The objectives of the validation was to i) ensure completeness and clarity of the loops and ii) avoid misrepresentation and duplication of variables. Results presented in table 1, together with a soft and hard copy of CLD's were presented to the validation team, who took approximately one month to complete the exercise. During this process, it was discovered that unnecessary dependencies were created resulting into duplicate loops. Also, some variables were over-represented, having many instances across the different categories of the CLD's. The researchers unanimously discussed this feedback and, where necessary, amendments were made to enhance on the quality of the CLD's.

Stage 5: Causal Loop Refinement.
After the validation process, all corrections and suggestions from the validation team were adequately addressed and all the CLD's refined. This feedback helped to make the CLD's understandable.

3 Discussion

This study revealed that several causal factors influence the adoption of eHealth in Uganda. Our major findings categorized these factors into six themes, i.e. awareness, access, external, individual, organizational and technological.

Awareness. The study revealed that the user's awareness of the existence of eHealth technologies plays a lot into their ability to adopt to a new technology. Several scholars [9, 15, 27, 28] underscore the relative importance of the user's knowledge of the benefits of digital health systems in influencing their adoption. This study noted that training ICT users has an uphill influence on someone's digital literacy and skill and indirectly increases one's knowledge of importance of telemedicine, as can be corroborated in other similar studies [29, 30]. Some studies [31] have gone ahead to advocate for supervised training as a way of improving user's commitment to eHealth systems. Making users aware of the digital health technologies can be achieved through sensitization both at organizational and personal basis. In a study conducted in Uganda [32], there was great emphasis to sensitize medical personnel in a bid to increase telemedicine adoption. In addition, the study noted that literacy has a positive impact on someone's awareness of ICT's, just as much as sensitizing managers and seniors.

Access. This study also unraveled access as an important aspect to eHealth adoption in Uganda. It was revealed that the ease of accessing digital technologies like computers and smart phones determined one's ability to adopt eHealth systems. As noted in previous research [28, 33–35] digital technologies have acted as media of information exchange among eHealth users hence, their availability greatly influences the use

of the same. Most eHealth systems are internet-based and as such, network coverage [9, 27, 36] signal transmission (Kakaire & Mwagale, 2010), internet services [28, 37] and the availability of the telecommunication infrastructure [32] significantly impacts communication. Likewise, telecommunication costs [32], access to outside computers and modems [28] and regular power blackouts [27, 28, 35, 38] were found to greatly influence one's ability to access and use eHealth systems.

External factors. This study also found out that uptake of eHealth can be influenced by external conditions that are beyond the control of a user or an organization. These factors include government policies like strict tax regimes [39], government support [32, 33], laws guiding telemedicine practitioners [32] and the availability of eHealth implementation frameworks [40]. Incidentally, these factors will either accelerate or have a downward influence on eHealth. A positive government influence as revealed in this study accelerates uptake of digital health technologies and vice versa. Similarly, cross sector support or partnerships [39] from either civil society organizations, non-governmental organizations or relevant ministries can strengthen the synergy between partners, promote linkages and be a pedestal for eHealth advocacy.

Individual factors. Throughout the synthesis of the data, it was revealed that users have a great part they play in technology acceptance and uptake. Various individual factors like willingness to use eHealth systems [41, 42], technophobia [7, 29, 34], self-efficacy [33, 38], education [7, 39, 43, 44], user motivation [35, 45] were discovered to affect usage. Also, user involvement in the development of the system [29, 42, 46–48], cultural inclination [29, 38, 40] and literacy levels [49] inherently determined the use of eHealth systems among different users. Specifically, it was revealed that technophobia had a negative influence on someone's enthusiasm towards new technology, which has a ripple effect on the willingness to use eHealth systems. Subsequently, the individual trust [7, 38, 43] towards the technology will, to a greater extent affect acceptability of the system. This study demonstrated that the low trust in the system creates fear for one to reveal their health condition [50]. These challenges can be addressed through conducting usability training [30, 49, 51], massive sensitization [33] and nominating local champions to spearhead the eHealth drive. Local champions [46, 52] are good change agents and are key liaisons between the users and other stakeholders.

Organizational factors. This study also revealed an interplay of organizational factors in the adoption of eHealth systems. Critical organizational factors influencing uptake of eHealth included; culture of information use [35], change management processes [9, 29, 38], organizational conflicts [33], relative priority [38] and existence of ICT policy [50, 53]. Special to note is that, the study identified the causality of these factors and it was noted that staff attrition affects staffing numbers, thus increasing the workload of the available staff, which if not dealt with appropriately will affect morale and escalate user resistance towards adoption of health systems. Similarly, other organizational factors such as availability of funds [33, 49] affects both the investment in eHealth systems and compensation or rewards extended to the staff. Without a strong organizational support, staff are more likely to be reluctant to use [41, 42] procurement processes are likely to be delayed [7], delayed or no routine performance reviews done [35], and poor planning and coordination [9].

Technological factors. The study further revealed that technological factors, core in any system, are very critical in determining systems' acceptance and use. Technological factors noted to have influence on eHealth adoption include but not limited to; software user-friendliness [35, 39, 54]; quality of service [29, 34, 50]; availability of computers [28]; scalability [7], security of data [55]. In addition, culturally sensitive systems [37], interoperable systems [29, 41], adopting co-design [35], usefulness of the system [56] and systems with complex data structures [38] further impact adoption. This research revealed the interdependence of these factors but specifically illuminating software user-friendliness as paramount because of its inherent role in system usage. The ease with which a user finds the system usable will inevitably cascade into adoption. In essence, an easy to use software will attract many users prompting to scale these systems to improve performance and efficiency of the same.

4 Conclusion

The objective of this study was to conduct a systematic review to unveil the barriers and facilitators of eHealth adoption in Uganda and subsequently establish their causality using the Systems Thinking approach. The study revealed that training users in ICT improves their digital literacy and general awareness about ICT, which improves their knowledge of telemedicine and subsequently changes their attitude towards the use of eHealth systems. It was further revealed that the high telecommunication costs are likely to affect the user's ability to access internet services, which has a downhill effect on the use of eHealth services. Subsequently, government support through enabling policies like laws to protect telemedicine practitioners, legal and regulatory frameworks and offering incentives has an uphill effect on eHealth adoption. It was further revealed that technophobia negatively affects someone's enthusiasm to use new technology, which affects ICT uptake hence reducing the willingness to use. Lastly, it was noted that technological factors such as software user-friendliness and usefulness positively influence adaptability paving way for organizations to put in place sustainability plans to encourage usage. eHealth trajectory in Uganda is still in its infancy hence, it is imperative for key players in the sector to painstakingly consider the contextual barriers of eHealth and capitalize on the facilitators if eHealth is to ensue. Future work to explore the maturity level of eHealth systems to ascertain the level of adoption is recommended.

Limitations of the Study: eHealth research specific to the Ugandan context is very limited, which made the search very difficult and narrow. There are very few experts in system's thinking in the country, which delayed the validation process.

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