FEeSU - A Framework for evaluating eHealth Systems Usability: A Case of Tanzania Health Facilities

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Abstract

Adopting eHealth systems in the health sector has changed the means of providing health services and increased the quality of service in many countries. The usability of these systems needs to be evaluated from time to time to reduce or completely avoid the possibility of jeopardizing the patients' data, medication errors, etc. However, the existing frameworks are not country context sensitive since they are designed with the mind-set of practices in developed countries. Such developed countries' contexts have different cultures, resource settings, and levels of computer literacy compared to developing countries such as Tanzania. This paper presents the framework for evaluating eHealth system usability (FEeSU) that is designed with a focus on developing country contexts and tested in Tanzania. Healthcare professionals, including doctors, nurses, laboratory technologists, and pharmacists, were the main participants in this research to acquire practice-oriented requirements based on their experience, best practices, and healthcare norms. The framework comprises six steps to be followed in the evaluation process. These steps are associated with important components, including usability metrics, stakeholders, usability evaluation methods, and contextual issues necessary for usability evaluation. The proposed usability evaluation framework could be used as guidelines by different e-health system stakeholders when preparing, designing, and performing the evaluation of the usability of a system.

Keywords: Usability metrics, Usability evaluation, Contextual issues, eHealth systems, Framework for usability evaluation

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1. Introduction

The application of information and communication technology (ICT) in healthcare has improved the quality of service in health institutions worldwide. According to the World Health Organization [1], 58% of the WHO member states have adopted eHealth systems. The countries' governments that have adopted eHealth systems have established several strategies and initiatives to enhance their implementation and improve the system's quality. Examples of developing countries that have made strategies and initiatives include Kenya, which has the National eHealth Policy 2016–2030, which aims to overcome pre- and post-implementation challenges [2]. In addition, the South African National Digital Health Strategy for 2019–2024 aims to enhance the efficiency and quality of healthcare services, establish an integrated platform, and create awareness for successful digital health [3].

Tanzania, as one of the developing countries, has also been introducing several eHealth policies and strategies to enhance the implementation and improvement of eHealth systems' quality. Examples of eHealth strategies in Tanzania include the National eHealth Strategy 2013–2018 and the recently introduced National Digital Health Strategy 2019–2024. The current strategy aims to improve healthcare services of high quality for all Tanzanians [4].

This rapid adoption of eHealth systems is catalyzed by the benefits of using such technology in the health sector. Among the benefits of adopting eHealth systems are cost savings, health safety improvement, health service accessibility, improved decision-making, reduced medical errors, and generally improved healthcare service delivery quality, etc. [5] [6]. These promising benefits have pushed many countries to adopt various eHealth technologies. Despite the adoption and initiatives that developing countries have taken, previous studies such as [7] [8] [9] and [10] show that the poor usability of those systems is the major challenge for the penetration of eHealth systems not only in developing countries but also in developed countries.

The term usability in this study is defined as the ability of the user to simply apply a system to accomplish goals that are anticipated with effectiveness and efficiency, resulting in user satisfaction with less cognitive effort, subject to the context of use. This definition demonstrates that "a usability problem" is anything that could interrupt the smooth usage of a system or create barriers to achieving the goal and hence lower the level of user satisfaction. Furthermore, the term eHealth system usability in this study refers to the ability of healthcare providers and other stakeholders to apply the eHealth system to accomplish the goal without experiencing difficulties either physically or cognitively while maintaining efficiency and data integrity. The level of usability of a system depends on its design, the technical and physical environment in which it is to be used, the characteristics of its users (e.g., education, experience, etc.), and the intended goal to be accomplished [11] [12] [13]. In developing countries, including Tanzania, eHealth systems face poor usability in different aspects, such as user-system interactivity difficulties, frequent system errors, poor data quality, and a lack of system interoperability. Task-technology mismatch and poor communication and collaboration among the healthcare providers within the health facility are other usability issues of the eHealth systems in developing countries [7] [8] [9] & [10].

The level of usability of a system is determined by choosing an appropriate evaluation framework with proper evaluation metrics [13]. The existence of a framework with proper usability metrics that contemplate the contexts of developing countries could be used as a guide to designing eHealth systems that fit the contextual issues to increase the usability of eHealth systems. Additionally, the usability evaluation framework will help in revealing the usability problems of the existing eHealth systems and rectifying them.

According to Msanjila and Afsarmanesh [14], a framework is a conceptual design that is used to address and solve complicated problems by specifying the procedures and outlining the methodology for each step to get the best possible overall result. The study in [14] further emphasizes that the framework must contain all necessary steps to complete the processes and provide the answer. As a result, the framework for usability evaluation summarizes the criteria that should be followed when preparing, creating, and performing the evaluation of a system's usability.

2. Existing Framework for Evaluating the Usability of eHealth Systems

This study focused on the usability of eHealth systems, specifically health management information systems (HMIS). Therefore, this discussion did not take into account the frameworks applied for evaluating eHealth systems that are specifically designed for particular departments, or any other small-scope systems such as laboratory management information systems (LIMS), electronic medical records (EMR), etc. HMIS is used to collect, store, analyze, and evaluate health-related data from various levels of health facilities (i.e., from community to national level) [15]. It is contrary to the LMIS and other eHealth systems designed specifically to store, and analyze data within a small scope of a single health facility, single health profession, or single department within the health facility.

Several usability evaluation frameworks have been used to evaluate various information systems. However, they are either not explicitly designed to evaluate eHealth systems or are designed for specific country contexts that could not necessarily fit into developing country contexts. The developing countries, including Tanzania, have the specific contexts that are necessary for being considered in a framework to guide the eHealth system developers. Such contexts include low-resource settings such as a low number of healthcare professionals, inadequate computers in health facilities, inexperienced computer users, and culture [16]. For example, in this study, we observed that due to the small number of healthcare professionals in health facilities, there are times when the nurses observe the changes in the patient and directly consult the laboratory technician to investigate according to the symptoms before the doctor arrives. This means that the systems must allow collaboration between the nurse and laboratory technician in emergency cases. Moreover, the inadequate number of doctors forces the eHealth systems to allow the outpatient department (OPD) doctor to access the inpatient department (IPD) records for follow-up of the patient who was first admitted to the OPD and later transferred to the IPD. This feature might be unnecessary in countries with adequate healthcare professionals.

The existing frameworks include ISO 9241-11:2018 [17], the Health-IT Usability Evaluation Model (Health-ITUEM) [18], the National Usability-Focused Health Information Systems Scale (NuHISS) [19], the Nielsen usability model [20], and the TAM model for usability factors [21]. The ISO 9241-11:2018 standard has many usability aspects and considers context issues such as user characteristics, tasks, environment, and technology compared to other generic usability evaluation frameworks. However, since it is a general usability evaluation framework for evaluating systems, products, and services, it lacks specific eHealth usability evaluation metrics. Additionally, there is limited information on its applicability in evaluating eHealth systems, particularly in developing countries. The eHealth system has unique contexts that should be considered during the design and evaluation processes. Among the unique contexts associated with healthcare are professional roles, medical activity-minded collaboration, physician-patient interaction, and cognitive workload [12] [13] [22].

Although NuHISS and Health-ITUEM are designed specifically for evaluating the usability of eHealth systems, they are precisely designed for evaluating a single type of user, such as nurses or doctors. Therefore, using a framework designed for specific healthcare professionals to fit multiple professionals might affect evaluation comprehension. In addition, eHealth systems have recently been integrated to incorporate all professionals because inter-professional collaboration in healthcare is inevitable [23]. Therefore, it is necessary to evaluate the system with all incorporated professionals to assess all attributes contributing to poor usability. This will also enable the evaluators to reveal usability problems associated with the collaboration features of a system, which cannot be found in a framework designed to evaluate a single professional.

To address the problem associated with the existing frameworks, this study has developed a new framework for evaluating eHealth system usability (FEeSU) that considers contextual issues relevant to developing countries. We considered the contextual issues as proposed in the Fit for Individuals, Tasks, Technology, and Environment (FITTE) framework and the usability metrics from the literature review. Therefore, this research used the FITTE framework as a backbone for determining the contextual issues for eHealth systems usability.

The FITTE highlights the contextual issues that are necessary for the system's usability evaluation, including the user's characteristics (individuals), tasks, resources and technology, and environments [11]. The FITTE framework has the advantage of showing the relationships between the contextual issues. Examples of these relationships include the relationship between the user and tasks, tasks and technology, the user and technology, and the environment, among all other contextual issues. FITTE provides a skeleton of a framework as it includes the essential contextual issues. Moreover, this research has considered various studies about the usability of health systems to ensure that the proposed framework includes both generic and specific usability metrics that are particularly applicable to evaluating the usability of health systems. Additionally, to guarantee that the framework applies to developing countries, the existing usability metrics were tested for validation in Tanzania's context, specifically using the government of Tanzania's hospital management information system (GoTHoMIS) system as a platform

[23].

3. Methodology

A survey was used in this study to collect both quantitative and qualitative data, whereas the quantitative data was collected using the questionnaire and the qualitative data through the interview. In this research, we applied purposive and random sampling techniques. The purposeful technique was used in selecting the interviewee participants, while random sampling was used for selecting participants for quantitative data through a questionnaire. First, we determined the target population after setting the criteria, which involved the consideration of three levels of health facilities, including health centers, district hospitals, and regional referral hospitals, to obtain the opinions of healthcare professionals working in multi-level health facilities. The second criterion was to ensure the participants are also users of the eHealth systems; thus, the GoTHoMIS system was used as a platform as it was widely installed in the country and it is a locally made system. Third, this study consulted the president's office, regional administration, local government (PO-RALG) officers, and GoTHoMIS system developers to determine the health facilities installed with all necessary modules of the GoTHoMIS system that enabled all health professionals to apply it in routine healthcare delivery. Fourth, since there was no existing document that expressed the exact statistics of the employees of the selected health facilities, this study used a revised policy for staffing levels for the Ministry of Health and Social Welfare departments, health service facilities, health training institutions, and agencies 2014 – 2019 [24] to estimate the population. Thus, this study used the minimum staffing requirements times the number of health facilities that have implemented a GoTHoMIS system with all modules needed for this study as presented in *Table 1*. It was found that 37 health centers, 29 district hospitals, and 1 regional referral hospital were installed with modules that enabled all healthcare practitioners to use the eHealth system in their daily routines.

Table 1: Target population using minimum staffing and number of health facilities

Professionals	Health centers	District Hospitals	Regional/referral	Total per professional
Doctors	4*37 = 148	24*29 = 696	64*1 = 64	**908**
Nurses	11*37 = 407	78*29 = 2,262	199*1 = 199	**2,868**
Medical Attendants	6*37 = 222	44*29 = 1,276	98*1 = 98	**1,596**
Pharmacists	1*37 = 37	4*29 = 116	9*1 = 9	**162**
Lab-tech	2*37 = 74	5*29 = 145	15*1 = 15	**234**
Accountants, cashiers	3*37 = 111	4*29 = 116	6*1 = 6	**233**
Social welfare	1*37 = 37	2*29 = 58	6*1 = 6	**101**
Medical record tech	2*37 = 74	3*29 = 87	4*1 = 4	**165**
ICT officer	0*37 = 0	1*29 = 29	1*1 = 1	**30**
Total	**30*37 = 1,110**	**165*29 = 4,785**	**402*1 = 402**	**6,297**
Total sampling frame = 6,297				

Based on the sampling frame this study applied a formula as proposed by de Vaus [25] to calculate a sample size as follows:

$n = N * [\frac{\frac{Z^2 * p *(1-p)}{e^2}}{N-1+\frac{(Z^2 * p*(1-p)}{e^2}}$ whereby $\boldsymbol{n}$ is the sample size, $\boldsymbol{N}$ is the population size and e is the level of accuracy (or margin error), Z is the critical value of the normal distribution at the confidence level of 95%, and p is the sample proportion. N = 6,297, e = 0.05 (at a confidence level of 95%), Z = 1.96 (at a confidence level of 95%), p = 0.5 (constant value).

Therefore, sample size $n = 6297 * [\frac{\frac{1.96^2 * 0.5 *(1-0.5)}{0.05^2}}{6297-1+\frac{(1.96^2 * 0.5*(1-0.5)}{0.05^2}}$ **= 363**

Fifth, there was no necessity to choose participants based on the locations as the criteria for multi-level, and the GoTHoMIS system installed with all modules was the main criteria, and they were limited to location. Therefore, the decision of which health facility should be used in this study was made through the consultation of the responsible ministry. As a result, six health facilities in Tanzania exist at three different levels: two health center-level facilities, including Makole (Dodoma) and Kachwamba (Geita); three district hospital-level hospitals, including Chato district hospital, Biharamulo designated district hospital, and UDOM hospital (Dodoma); and one referral-level hospital, the Coastal Region Referral Hospital (Tumbi Hospital). The selection of these health facilities was done through consultation with the system developers from the PO-RALG office. The main criteria were to involve the health facilities that are installed with GoTHoMIS Lite (or version 4), which have all necessary modules that enable multiple healthcare professionals to use the system and should include three levels, including health centers, district hospitals, and regional referral hospitals.

Based on these criteria, in consultation with the PO-RALG officers, the selection was made. To ensure sufficient returns of the answered questionnaire, this study decided to distribute a questionnaire to participants by adding 10% more than the calculated sample size. As a result, 370 (101.9%) were returned. Moreover, this study selected 21 participants in consideration of the work experience of not less than 3 years, including healthcare practitioners (doctors and nurses), system developers, and ICT support personnel as presented in *Table 2*.

Table 2: Interviewee participants

Health facility level	No of HF	No. of participants/HF	Total
Health centers	2	2	4
District Hospitals	3	3	9
Regional referral Hospitals	1	4	4
Developers and ICT support personnel	-	4	4
Total			**21**

Quantitative data was applied to isolate metrics that were not suitable for inclusion in the framework from the pool of many metrics obtained from the literature. For qualitative data, 21 experienced healthcare practitioners and ICT personnel were interviewed to add metrics and items that could not be foreseen in a quantitative research tool based on their experience and best practices. The aim of conducting a survey was to acquire the usability metrics and contextual issues that apply to evaluating the usability of eHealth systems. Thus, the contextual issues as proposed in the FITTE [11] and usability metrics from the literature review were tested using confirmatory factor analysis (CFA) through structural equation modeling (SEM) analysis to reveal those that are suitable in Tanzania's environment.

The framework development process passed through five phases, including problem identification, problem analysis, design and analysis, developing a framework, and validating the framework. Phase 1 dealt with problem identification, whereas a preliminary interview was conducted with healthcare professionals to confirm the existence of challenges to the usability of eHealth systems. Additionally, the concept was presented to HCI gurus through a conference named the AfriCHI Conference in March 2021 to acquire opinions for improving a study. Moreover, a scoping review was conducted, whereby 15 articles from three journal databases, including Emerald, PubMed, and SAGE, met the criteria for inclusion. The search phrases were "usability" along with "metrics" "evaluation metrics" "factors" "attributes" "framework" "models" "taxonomy" "eHealth" "health" "telehealth" and "mHealth". Only research written in English was taken into consideration for the reviewed papers, which were limited to articles published from 2012 to 2021. As a result, the metrics that appeared at a high frequency (at least four times) in these 15 articles were considered. Additionally, data from the opinions of healthcare practitioners and local eHealth system developers was collected through an unstructured interview. Besides, usability evaluation models and frameworks such as ISO 9241-11, the Nielsen model, NuHISS, Health-ITUEM, and TAM for usability factors were reviewed to capture common metrics applied in evaluating eHealth systems. Furthermore, the FITTE framework was reviewed to capture the contextual issues as applied in health systems. This process resulted in obtaining the usability metrics and contextual issues required for evaluating the usability of eHealth systems. In the problem analysis stage, the research tools (i.e., questionnaire and interview guide) were developed and used in data collection from the participants.

In *phase 2,* the research tools, including the questionnaire and interview guide, were designed with the support of literature reviews and reviews of various standardized questionnaires for usability evaluation. *Phase 3* dealt with data analysis; thus, quantitative data was analyzed by conducting the CFA through SEM analysis to validate the metrics and contextual issues that are applicable in developing countries, specifically Tanzania. As a result, 11 usability metrics and 5 contextual issues with 72 items were analyzed to test the model fit. Those items that scored low factor loadings (i.e., items with factor loadings less than 0.7) [26] [27] were eliminated from the model. For qualitative data, thematic analysis was used to acquire other metrics based on the opinions and feelings of the respondents according to experience and best practices. *Phase 4* of developing a framework was conducted by including the results from phase 3 and also supporting them with other knowledge that was necessary for the framework, such as evaluation methods, important stakeholders to be involved, and evaluation framework guidelines. Lastly, in *phase 5*, the framework was validated by conducting a focus group discussion that included three local eHealth system developers and three experienced healthcare practitioners. *Figure 1* illustrates the procedures taken to develop a framework for evaluating the usability of an eHealth system.

4. Results and Discussion

This section presents the results of the validated usability metrics and contextual issues necessary for evaluating eHealth systems. The section begins by presenting the demographic data of the participants, whereas, a sample of 370 from six health facilities in Tanzania was used in this study.

*Table **3*** presents a summary of the demographic data to show the diversity of the participants involved in this study.

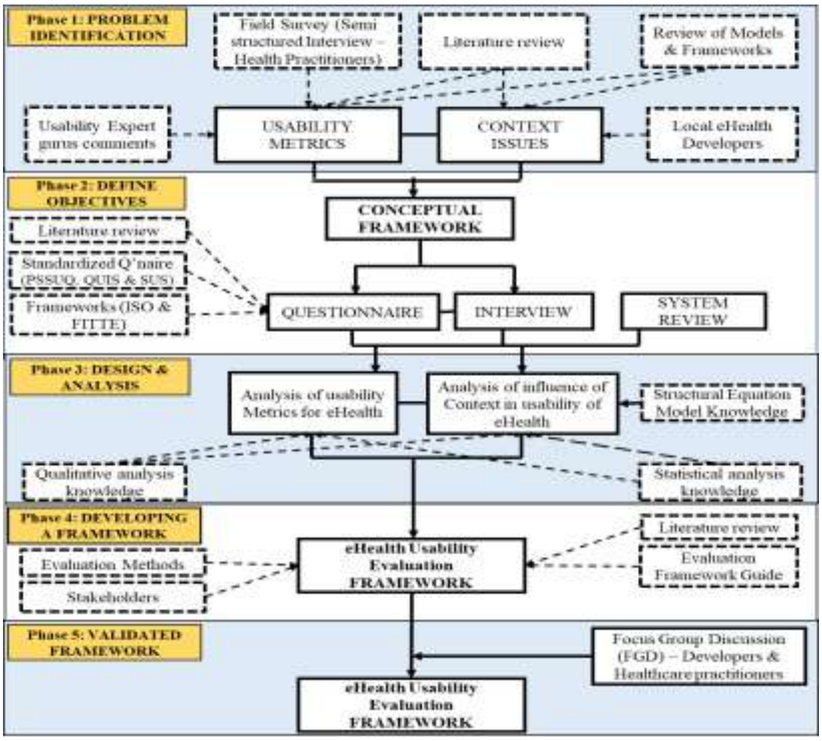

Figure 1: Framework development phases

Table 3: Demographic data of the respondents

Variable	Items	Frequency (N)	Percentage (%)
Gender	Male	164	44.3
	Female	206	55.7
Total		**370**	**100.0**
Age group	18 – 24 years	17	4.6
	25 – 34 years	179	48.4
	35 – 44 years	81	21.9
	45 – 54 years	77	20.8
	55 – 65 years	16	4.3
Total		**370**	**100.0**
Occupation role	Physician/Doctor/Clinician	109	29.5
	Pharmacist	35	9.5
	Lab technologist	44	11.9
	Nurse/Midwifery/Anesthetists	143	38.6
	Accountant	16	4.3
	ICT	2	0.5
	Reception/Data Clerk	11	3
	Other	10	2.7
Total		**370**	**100**
Academic qualifications	Form Four	37	10.0
	High school	3	0.8
	Certificate	56	15.1
	Diploma	159	43.0
	Bachelor degree	107	28.9
	Master degree	8	2.2
Total		**370**	**100.0**
Health facilities levels	Regional Referral Hospital	155	41.9
	D/DDH	181	48.9
	Health Center	34	9.2
Total		**370**	**100.0**
Health facilities names	Biharamulo DDH	65	17.6
	Chato DH	71	19.2
	Kachwamba HC	9	2.4
	Makole HC	25	6.8
	Coastal RRH (Tumbi)	155	41.9
	UDOM Hospital	45	12.2
Total		**370**	**100.0**

4.1. Usability metrics for evaluating eHealth systems

From the quantitative data analysis, this research has established eleven (11) usability metrics that are classified into two categories namely: common metrics constituting navigation, accessibility, visibility, and perceived ease of use; and specific metrics constituting collaboration, information quality, and terminologies, technical qualities, guide and support, and perceived benefits of the system. Common metrics in this context are the metrics that are used in evaluating generic information systems, and or other products. Specific metrics are those which are mostly used in evaluating the usability of the eHealth systems. Each of these metrics comprises several measurement items. In testing the applicability of the metrics using the CFA, some items statistically failed to prove applicability as their factor loadings were below the threshold of 0.7 and caused the model unfit. Therefore, in the process of modifying the model, the items with low factor loadings were eliminated from their corresponding metrics. For example, three items in the variable perceived ease of use including PEOU1, PEOU2, and PEOU6 with extremely low factor loadings such as 0.459, 0.454, and 0.282 respectively were eliminated from the model. The CFA results were improved to model fit for all goodness indices such as CMIN/DF (χ^2/df) = 2.663, CFI = .937, TLI = .924, GFI = .904, AGFI = .871, and RMSEA =.067. The details of the results of the CFA are presented in our paper in [28].

Table 4 presents the summary of the metrics and their items that were obtained from literature and various models after performing CFA and finally added with items resulting from the interview (qualitative data). The results depict that the analysis began with 5 constructs of common metrics with 25 metrics, but they were deducted after performing CFA as the error correction metric (with 7 items) did not show a correlation with other common metrics. Additionally, 3 items from perceived ease of use were eliminated as they had low factor loadings. Besides, specific metrics were 6 metrics and be added by one (error correction metric with 7 items). Subsequently, the results of the qualitative metrics added 7 items (2 in common metrics and another 5 in specific metrics), which were later merged into the related metrics confirmed through quantitative analysis. For contextual issues, the constructs were five from the beginning to the end, though after the CFA 6 items were eliminated due to low factor loadings

Table 4: Usability Metrics Extraction

Usability metrics	Metrics and (items)	Metrics and (items) after CFA	Items added from qualitative	Total metrics
Common metrics	5(26)	4(16)	2	4(18)
Specific metrics	6(25)	7(32)	5	7(37)
Total metrics	**11(50)**	**11(48)**	**7**	**11(55)**
Contextual issues	5(22)	5(16)	0	5(16)

The metric navigation is aimed at measuring how easy it is to understand how to move from one page (or screen) to another, a system has a consistent layout and has the correct links to the correct tasks. Visibility is the common metric that is used in assessing whether the icons, pictures, and fonts are clear, readable, and attractive. The system should make it easy to access information and enter data without taking away the attention of the user (in this case, a doctor) from the patient during the diagnosis. Also, the system should be easy to use in terms of being easy to learn at first and easy to remember when the user has not used it for a while. Additionally, although the metric error correction has been used in evaluating generic information systems and thus be categorized as a common usability metric, it has shown to have more importance in evaluating the usability of eHealth systems. This was proved statistically, whereas, the metric showed more significance in influencing the usability of the eHealth system when grouped with other specific metrics than when it was grouped with other common metrics [28]. Therefore, this study has categorized error correction as the specific metric for evaluating eHealth systems. Error correction tests the ability of a system to cancel the process, undo the action, avoid duplicates, and provide alerts and warnings to prevent errors from occurring.

Moreover, a metric for information quality and terminologies is the specific metric for evaluating eHealth systems that are used to assess the quality of the information in the system, such as laboratory results, patients' medication lists, the ability to generate a summary of the patient's health status, clear and understood medical terminologies, etc. The technical quality metric deals with the suitability of the technical functionality (no downtimes) and the ability of the system to retain data. Collaboration metrics (both internal and external) assess the ability of the system to allow the interaction of stakeholders within and outside the health facility. For example, Internal collaboration measures the ability of the system to allow interaction between healthcare professionals and inter-department interaction, while external collaboration assesses the ability of the system to allow external stakeholders such as the government authorities to access the statistical data, interaction with outside stakeholders such as suppliers, and interaction with other health facilities, for example, on referral cases. Guide and support is the metric used to assess how the system provides enough instructions to accomplish the tasks accurately and can notify users when a current task is taking place, such as saving data, sending or delivering messages, and updating. The metric named benefits assess how the system improves the quality of care.

*Table **5*** presents the usability metrics constructs corresponding to their measurement items, along with the codes per item as used in the analysis. The green highlighted items were added from the qualitative results.

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Table 5: Usability metrics for evaluating eHealth systems

Constructs	Code	Measurement items
Common Usability Metrics		
Navigation	NAV1	Ability to "go back" to the previous screen
	NAV2	Easy to go to the next screen
	NAV3	Ability to predict the following procedure
	NAV4	The consistency of the system's layout from screen to screen.
	NAV5	No need to stop and think about which icon to click
	NAV6	Correct icon or link to navigate to the correct task
Perceived ease of use	PEOU3	The system is easy to learn how to use
	PEOU4	The system is easy to remember how to use (it does not take me long to recall the process)
	PEOU5	Ease to cope with the system skilfully
	PEOU7	It is simple to enter data into the system
Visibility	V1	Pictures, icons, texts, and links on the screen are visible
	V2	The interface of eHealth is attractive
	V3	The fonts (style, color) are easy to read in on-screen
Accessibility	ACC1	eHealth system supports diverse users to accomplish tasks
	ACC2	Ability to serve patients easily while entering data into the system
	ACC3	Ability to use the system without taking away the attention of the patient
	ACC4	The system does not demand extra cognitive workload while performing tasks
	ACC5	The ability of the OPD doctor to access the IPD patients' information
Specific eHealth Usability Metrics		
Error Correction	EC1	Reminders, alerts, and warnings to avoid errors
	EC2	Ability to cancel the process before completion
	EC3	Default values to select and check for validity
	EC4	Ability to undo action to avoid errors
	EC5	Popup message to understand what is going on
	EC6	Ability to avoid duplicate tests and examinations
	EC7	Recover easily from errors and mistakes
External Collaboration	EXTCOL1	The eHealth system allows government authorities to access the statistical data and influence its usability
	EXTCOL2	The system allows interaction with other health facilities
	EXTCOL3	The information on medications ordered in other organizations
	EXTCOL4	I can obtain patients' information from other health facilities quickly
	EXTCOL5	The system supports cooperation and communication between doctors working in different health facilities
Internal Collaboration	INT COL6	The system supports cooperation and communication between healthcare multi-professionals
	INT COL7	I can work together with other members (other health professionals) from other departments through the eHealth system
	INT COL8	The work of one user does not interrupt the work of another user in the system
	INTCOL9	Ability of lab technician to communicate pending investigation results to the doctor (e.g., bacteria culture test)
	INTCOL10	The ability of the system to allow collaboration between nurse/midwife and lab technician when necessary to rescue emergency cases
	INTCOL11	The ability of the lab technician to advise the doctor on the newly discovered disease as a result of the investigation.
Benefits	BEN1	The systems help to improve the quality of care
	BEN2	The system helps to ensure continuity of care
	BEN3	The system provides information about the need for and effectiveness of treatment of the patients
Technical Quality	TQ1	The system is stable in terms of technical functionality (does not crash, no downtime)
	TQ2	The system has never caused serious adverse events to the patient's safety/health
	TQ3	The system responds quickly to inputs
	TQ4	Information entered/documented never disappears from the system
	TQ5	There is quick help whenever the problem occurs
Info Quality & Terminologies	IQ1	The laboratory and diagnostic imaging results are easily available and logically presented
	IQ2	The patient's medication list is presented in a clear format
	IQ3	eHealth system generates a summary view that helps to develop an overall picture of the patient's health status

	IQ4	Terminologies on the screen are clear, and understandable (e.g., titles and labels)
	IQ5	Patients' data are comprehensive, up-to-date, and reliable
	IQ6	Ability to maintain data after sending it to another department
	IQ7	Ability to eliminate investigation tests for patients who choose to leave before treatment
Guide and support	GF1	The system provides sufficient information about the patient's progress.
	GF2	The system provides enough information and instructions, help to accomplish tasks accurately
	GF3	The system monitors and notifies when the orders given to nurses have been completed
	GF4	The system informs about what it does (e.g., saving data, message delivery, data updated, etc.)

Furthermore, the usability evaluation of the eHealth system, like other information systems, depends on contextual issues. These contexts, as proposed by Prgomet et al. in [11], include: user characteristics that emphasize the individual characteristics that affect the ability to use the system; goals and tasks are another context that measures how the system can accomplish the tasks (i.e., complexity, organization of tasks, etc.); resource and technology measure the availability of resources that enable the system to be used; the technical environment measures the availability of the technical resources, including the internet and electricity, and how reliable they are to facilitate the usability of the system. The physical environment deals with the physical office space, safety, and comfortability, as also presented in *Table 6*.

Table 6: Contextual Issues

Constructs	Code	Measurement items
Users' Characteristics	UC1	The contribution of the previous experience to the current system's usability
	UC2	The contribution of training on the usability of the eHealth system
	UC3	The contribution of the knowledge of computers in using the eHealth system
Goals and Tasks (GOALS)	GT2	Routine tasks are performed straightforwardly without the need for extra steps
	GT3	The tasks are well organized in the system to allow smooth recording and retrieving of information.
	GT4	Ability to perform healthcare tasks easily compared to manual system
Resources and Technology (REST	RT1	The quality of the hardware and software is sufficient to enhance the usability of an eHealth system
	RT2	The information is relevant and well understood (use of common language to the user)
	RT3	There is a system-support-personnel to solve the problem with the system
Physical Environment (PHYS	EP1	The office has enough space to work with the computer system
	EP2	The working environment is safe to protect the users' physical, legal, confidentiality, and property
	EP3	There is enough space, safety, and comfort for working with the system
Technical Environment (TECH	TE1	The health facility has enough computers
	TE3	The speed of the computers available is good enough to accomplish the tasks quickly.
	TE4	There is no high frequency of internet outages (internet problem)
	TE5	The eHealth system allows working offline (without internet)

4.2. The FEeSU Framework

Studies such as [14] and [29] highlight that the framework must include all necessary actions to accomplish the processes and generate the solution. On this basis, this paper proposes the FEeSU framework, which consists of six steps, including engaging stakeholders, familiarizing the system, choosing evaluation methods, gathering evidence, justifying the conclusion, and disseminating the results, as illustrated in ***Error! Reference source not found.*** These steps are interrelated.

The first step aims to engage various stakeholders not only for awareness but also to prepare them for data collection. For example, the Ministry of Health is involved only to be aware of the exercise that is to be taken and its impact on healthcare services. Engaging this high authority is expected to help with the implementation of the solutions that will be proposed based on the results of the evaluation process. Other stakeholders are expected to be involved in data collection as they will directly participate in the evaluation exercise. Once awareness is created among the stakeholders, the next step is to become familiar with the system. The evaluator will use the stakeholders to gather information about the system, its goal, and the expectations that are intended, as well as to study the contexts of use (i.e., the environment, the level of user understanding of the use of the system, the system's development life cycle stage, etc.). The familiarization of the system leads to the determination of the method by which the usability evaluation should be conducted. This is possible only if the evaluator has enough knowledge about the system, including its level of maturity (i.e., the system's development life cycle stage). Once the evaluation method is known, the evaluator can start gathering evidence using that method. The tool for gathering evidence is expected to be developed using the usability metrics set by this framework. The evidence will be analyzed, and the conclusion will be provided and categorized from the critical issues to the simple issues. At this stage, suggestions for actions to be taken to rectify the observed issues are also given. Lastly, the report of the usability evaluation shall be disseminated to the stakeholders for action. The following paragraphs discuss in detail each step of this framework.

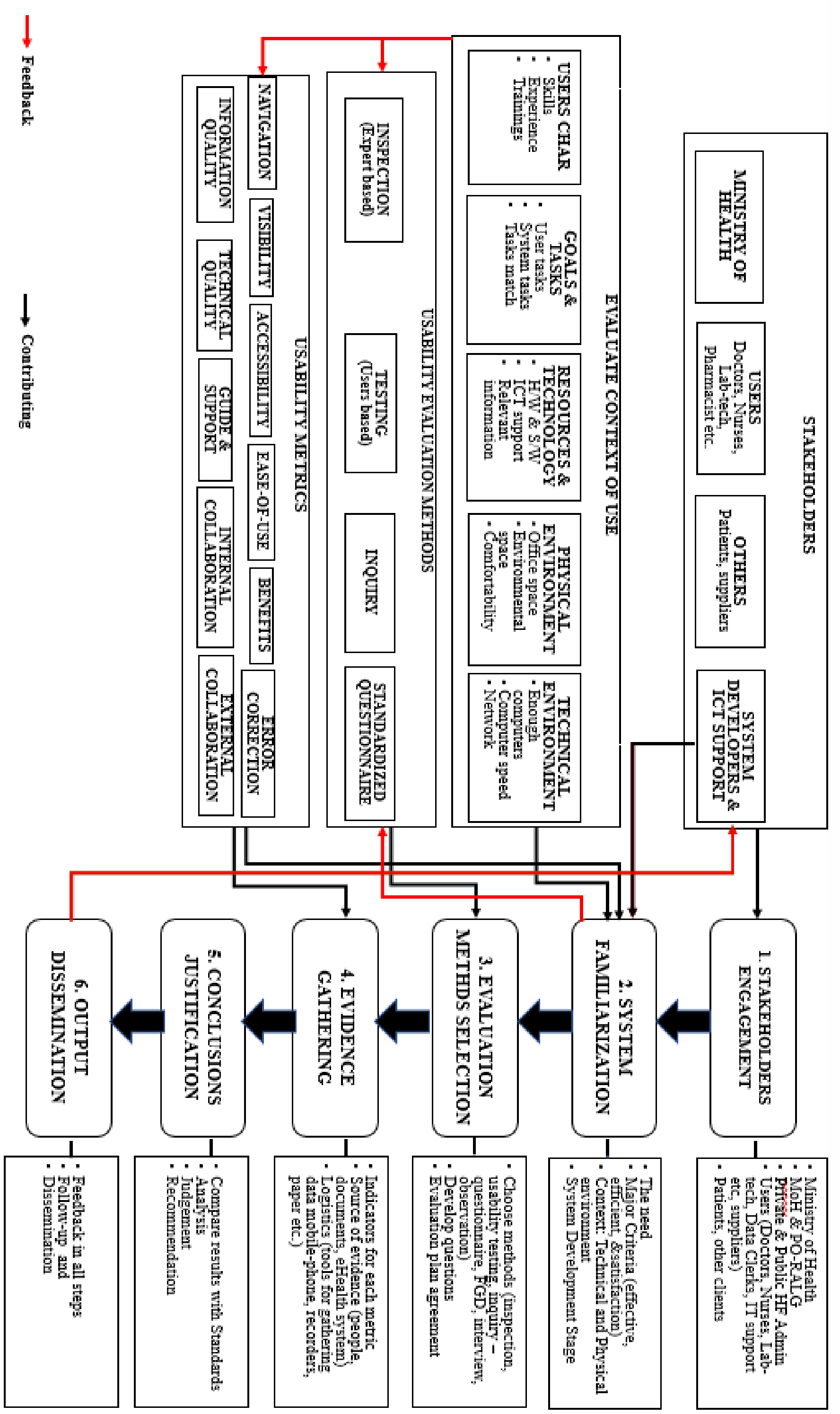

Figure 2: A Context-Specific Framework for Evaluating eHealth Systems' Usability (FEeSU)

Step 1: Engage Stakeholders: The purpose of engaging stakeholders in the evaluation process is to create awareness and increase acceptance of the system and the changes that could be made after the evaluation. Additionally, ignoring the engagement of the stakeholders in the evaluation process can lead to resistance, criticism, and ignoring the findings [30]. In this context, stakeholders are the people or organizations that are affected by the results of the use of the eHealth system. Stakeholders include those who are involved in a system's operation, those who are affected by the system directly or indirectly, and those who are the primary users of the eHealth system.

In this context, the primary stakeholders in evaluating the usability of the eHealth system are the users of the system (i.e., doctors, nurses, lab technicians, pharmacists, data clerks, accountants, etc.) who are daily interacting with the system. Additionally, patients and their network of informal care providers (relatives, family, friends, community health workers, community leaders, and neighbors) are the stakeholders who are either direct users or directly or indirectly affected by the results of the usability of the eHealth system. This is because, in the management of chronic or communicable diseases, the aforementioned stakeholders also participate in the decisions related to the adoption, acquisition, and acceptance of some technologies. As such, usability evaluation for such an e-health system needs to consider this group of stakeholders as well.

Other organizational stakeholders that are also very important in this framework include government authorities, regulatory boards, and private healthcare provider organizations management. Generally, the health sector in Tanzania comprises stakeholders from several organizations, including government institutions and private sectors such as faith-based organizations (FBOs) and other organizations, namely private for-profit (PFP) organizations [31].

Step 2: System familiarization: The evaluator of the system must be acquainted with the objectives or goals that the system is intended to achieve. Detailed information about the system should be well-known to the evaluator. Evaluating a system without a clear understanding of its definition is likely to be ineffective. This definition of a system should encompass all necessary aspects, including the need, the expected results, activities, resources, stage of development, and context. The evaluator needs to be familiar with the goals expected to be accomplished by the system, such as enhancing clinical decision-making, helping users manage their health information, allowing doctors to store and retrieve patient information, etc. Additionally, the evaluator is required to be familiar with the context in which the system is operating, including the availability of the internet, computer speed, and the users' experience.

Moreover, through consultation with experienced practitioners, the evaluator shall be well-informed of the metrics that will be used to assess the usability success of the system. In this study, navigation, visibility, accessibility, ease of use, internal and external collaboration, information quality and terminologies, technical quality, guide and support, perceived benefits, and error correction are the proposed metrics for evaluating eHealth systems. Consequently, being familiar with the system also includes knowing about the level of maturity of the system, such as its planning, implementation, or effect stage. Each level of maturity determines which usability valuation method should be applied.

Step 3: Choose Evaluation Methods: Based on the maturity level of a system, an evaluator can decide which usability evaluation method to use in the evaluation process. Common usability evaluation methods include inspection (expert-based), testing (user-based), inquiry (interviews and focus group discussions), and questionnaires. For example, if the system is in the effect stage (i.e., has been used for a long time), the evaluator may apply a questionnaire to receive the opinions of the users, and the evaluation in this stage is mainly done for improving operations or overhauling the system. In the implementation stage, the system is evaluated using the testing method. Moreover, qualitative methods such as focus group discussions and interviews can be applied in evaluating the implemented eHealth system to acquire the usability discrepancies discovered after the use of the system.

Step 4: Evidence Gathering: This is the most important stage in the usability evaluation of the eHealth systems. The questions formed based on the identified usability metrics and tested for their validity will reveal the usability issues that are perceived as credible and relevant by the stakeholders. Usability metrics that are essential in evaluating eHealth systems, as tested in Tanzania, are presented in step 2 of this framework.

The evaluator should properly select the participants in the evaluation process. For example, novice users or experienced users could participate, depending on the purpose of the evaluation. If the purpose of the evaluation is to make policy or overhaul the system, the experienced users are important, and if the system is in the implementation stage and the purpose of the evaluation is to propose a modification, both novice and experienced users could participate. Thus, the novice user will help identify how the system is easy to learn, remember, and efficient, while the experienced user will share the level of errors and how it can accomplish the goal.

Step 5: Conclusion Justification: A good conclusion is based on the evidence gathered (findings) and judged based on the standards set by stakeholders. The evaluator should be able to classify those critical issues and those simple issues revealed in the evaluation. The judgment statements will indicate the level of usability of the system and the implications or consequences that could happen or have happened due to the usability issues identified.

Step 6: Dissemination of the Findings: In this step, the reports are disseminated to the stakeholders. It is the work of the management and evaluator to identify who should receive the report and deal with the particular issue. Although the dissemination of the evaluation results is the last step, its smoothness starts at the beginning of the evaluation exercise. For example, a clear description of the evaluation process helps identify the relevant stakeholders who are involved and will receive the report. To ensure that the stakeholders can fully comprehend the final report of the findings, feedback should be offered at each stage by holding regular meetings with them. Lastly, the evaluator and the management of the health facility or other authorities should follow up to identify and avoid those who usually undermine or misuse the findings by disregarding the positive side of the findings.

Furthermore, this framework is designed to accommodate various stakeholders in evaluating eHealth systems. The application of the framework will vary based on who uses it. For example, the involvement of the stakeholders in evaluating the public health facility will differ from private health facility. This is because while the evaluation of the public health facility needs to involve the government authorities, the private healthcare providers will need to involve the top management of the particular organization only.

4.3. Framework innovation

The innovation of this framework is based on the inclusion of the different components together to ensure that not only the evaluation exercise is performed smoothly and can reveal usability issues, but also that the revealed issues are taken seriously and corrected timely. This is possible as the evaluation process involves the highest authorities and all important stakeholders. Other components, such as evaluation methods, usability metrics, and contextual issues, together make this framework more comprehensive compared to other usability evaluation frameworks.

In addition to ISO and FITTE, several other frameworks, such as Health ITUEM, Nielsen Usability Model, and NuHISS, have neglected to address the significant contextual factors that play a crucial role in usability evaluation. Moreover, it is worth noting that while both the FITTE framework and the ISO 9241-11 consider contextual factors, they do not provide explicit metrics for evaluating the usability of eHealth systems. The FITTE framework was primarily designed to facilitate the adoption of eHealth systems, while ISO 9241-11 focuses on the overall usability of various systems, products, and services. Furthermore, the existing frameworks for assessing the usability of systems lack guidance regarding the inclusion of individuals outside of direct users in the process of usability evaluation. The FEeSU framework possesses contextual specificity, involves important stakeholders, and incorporates six sequential processes rendering it a valuable framework compared to other usability evaluation frameworks currently available.

This framework was developed in consideration of the opinions of various healthcare professionals and developers. Additionally, this framework was developed based on the context of the country, which has limited resources such as manpower, computers, electricity, and the Internet. For example, due to the limited number of doctors, this study showed that for the eHealth system to be usable, the same doctor attending the OPD should be able to follow up with the patient who was admitted or transferred to the IPD. The current system does not allow the doctor in the OPD to access the information of the patient who was transferred to the IPD.

This framework recognizes professional roles as it considers various professionals and how they should collaborate. For example, the research revealed that the eHealth system is usable if the internal collaboration between laboratory technicians and doctors and between laboratory technicians and nurses is considered. This is because healthcare provision is completed with the collaboration of several professionals. Additionally, the framework considered physician-patient interaction and cognitive workload, as some metrics are intended to measure how the system is simple to use and does not cognitively overwhelm the physician, as well as how the healthcare professional (user) can use the system to enter data while communicating with the patient. Examples of these metrics include "the ability to serve patients easily while entering data in the system", "the ability to use the system without taking away attention from the patient", and "the ability to work together with other members (other health professionals) from other departments through the eHealth system". Other metrics that enhance this framework to consider specific contexts include "the ability of the system to allow collaboration between nurse/midwife and lab technician when necessary to rescue emergency cases" and "the ability of the lab technician to advise the doctor on the newly discovered disease as a result of the investigation".

5. Conclusion

This paper presented the framework for evaluating eHealth systems usability (FEeSU) that comprises six steps, including engaging stakeholders, familiarizing the system, choosing an evaluation method, gathering evidence, justifying the conclusion, and disseminating the results. These steps are associated with the components of the framework, including stakeholders (those who are directly or indirectly interacting with or affected by the system), usability metrics, usability evaluation methods, and contextual issues. The skeleton of the FEeSU was generated from the FITTE framework. The specific usability metrics are extracted from the literature and tested in Tanzania contexts; as a result, 11 metrics with their items are proposed with the framework to be applied for evaluating eHealth systems in Tanzania and other countries with similar contexts to Tanzania. Additionally, since the metrics proposed in this paper are tested on the GoTHoMIS system platform only, this research recommends further studies to focus on testing the proposed usability metrics and the applicability of the framework at large on other eHealth systems for generalizability.

References

[1] World Health Organization, "Global diffusion of eHealth: making universal health coverage achievable," WHO, Geneva, 2016.

[2] Republic of Kenya, "Kenya National eHealth Policy 2016 – 2030," Republic of Kenya: Ministry of Health, Nairobi, 2016.

[3] Republic of South Africa, "National Digital Health Strategy for South Africa," National Department of Health, Pretoria, 2019.

[4] Ministry of Health, Community Development, Gender, Elderly and Children, "Digital Health Strategy July 2019 - June 2024," United Republic of Tanzania, Dodoma, 2019.

[5] M. Botha, A. Botha, and M. Herselman, "The Benefits and Challenges of e-Health Applications: A Content Analysis of the South African context," in *Proceedings of the International Conference on Computer Science, Computer Engineering, and Social Media*, Thessaloniki, Greece, 2014.

[6] T. Abolade and A. Durosinmi, "The Benefits and Challenges of E-Health Applications in Developing Nations: A Review," in *Proceedings of the 14th iSTEAMS International Multidisciplinary Conference*, Ilorin, Nigeria, 2018.

[7] O. Taiwo, O. Awodele and S. Kuyoro, "A Usability Framework for Electronic Health Records in Nigerian Healthcare Sector," *International Journal of Computer Science Engineering (IJCSE),* vol. 5, no. 1, pp. 16-20, 2016.

[8] M. Gregory and S. Tembo, "Implementation of E-health in Developing Countries Challenges and Opportunities: A Case of Zambia," *Science and Technology,* vol. 7, no. 2, pp. 41-53, 2017.

[9] J. Peltola, "Adoption and Use of Hospital Information Systems in Developing Countries: Experiences of Health Care Personnel and Hospital Management in Tanzania," Tampere University, Tampere, 2019.

[10] J. S. Mtebe and R. Nakaka, "Assessing Electronic Medical Record System Implementation at Kilimanjaro Christian Medical Center, Tanzania," *Journal of Health Informatics in Developing Countries*, pp. 1-16, 2018.

[11] M. Prgomet, A. Georgiou, J. Callen, and J. Westbrook, "Fit Between Individuals, Tasks, Technology, and Environment (FITTE) Framework: A Proposed Extension of FITT to Evaluate and Optimise Health Information Technology Use," *International Medical Informatics Association (IMIA),* pp. 744-748, 2019.

[12] M. Broekhuis, L. Velsen, and H. Hermens, "Assessing the usability of eHealth technology: A comparison of usability benchmarking instruments," *International Journal of Medical Informatics,* vol. 128, pp. 24-32, 2019.

[13] V. E. C. Sousa and K. D. Lopez, "Towards Usable e-Health: A Systematic Review of Usability Questionnaires," *Applied Clinical Informatics,* vol. 8, pp. 470-489, 2017.

[14] S. S. Msanjila and H. Afsarmanesh, "FETR: a framework to establish trust relationships among organizations in VBEs," *Journal of Intelligent Manufacturing,* vol. 21, p. 251–265, 2010.

[15] W. B. Hamad, "Current position and challenges of eHealth in Tanzania: A review of literature," *Glopbal Scientific Journal (GSJ),* vol. 7, no. 9, pp. 364-376, 2019.

[16] International Standards Organization, "ISO-9241-11:2018 Ergonomics of human-system interaction — Part 11 Usability: Definitions and concepts," ISO, Switzerland, 2018.

[17] W. I. Brown, R. Schannal, M. Rojas and P.-Y. Yen, "Assessment of the health IT usability evaluation model (Health-ITUEM) for evaluating mobile health (mHealth) technology," *Journal of Biomedical Informatics,* vol. 46, no. 6, pp. 1080-1078, 2013.

[18] H. Hyppönen, J. Kaipio, T. Heponiemi, T. Lääveri, A.-M. Aalto, J. Vänskäi and M. Elovainio, "Developing the National Usability-Focused Health Information System Scale for Physicians: Validation Study," *Journal of Internet Medical Research (JIMR),* vol. 21, no. 5, p. e12875, 2019.

[19] J. Nielsen, Usability Engineering, San Francisco: Mogan Kaufmann, 1993.

[20] S. A. Burney, S. A. Ali, A. Ejaz, and F. A. Siddiqui, "Discovering the Correlation between Technology Acceptance Model and Usability Model and Usability," *International Journal of Computer Science and Network Security (IJCSNS),* vol. 17, no. 11, pp. 53-61, 2017.

[21] J. E. Squires, L. D. Aloisio, J. M. Grimshaw, K. Bashir, K. Dorrance, and M. Coughlin, "Attributes of context relevant to healthcare professionals use of research evidence in clinical practice: a multi-study analysis," *Implementation Science,* vol. 14, no. 52, pp. 1-14, 2019.

[22] B. Bosch and H. Mansell, "Interprofessional collaboration in health care: Lessons to be learned from competitive sports," *Canadian Pharmacists Journal (CPJ),* vol. 148, no. 4, pp. 176-179, 2015.

[23] Ministry of Health and Social Welfare, "Staffing levels for Ministry of Health and Social Welfare departments, health service facilities, health training institutions, and agencies 2014-2019: Revised," The United Republic of Tanzania, Dar es Salaam, 2014.

[24] D. de Vaus, Surveys in social research, 6th ed., London: Routledge, 2014.

[25] R. B. Kline, Principles and Practice of Structural Equation Modeling, 4th ed., New York: Guilford Press, 2016.

[26] J. F. Hair, W. C. Black, B. J. Babin and R. E. Anderson, Multivariate data analysis, 7th ed., Edinburgh Gate, UK: Pearson Education Limited, 2014.

[27] K. Kavuta, S. Msanjila and N. Shidende, "Validation of Usability Metrics for Evaluating eHealth systems in Tanzania," *East African Journal of Information Technology,* vol. 6, no. 1, pp. 201-218, 2023.

[28] M. Coxa, S. Villamayor-Tomas, G. Epstein, L. Evans, N. C. Ban, F. Fleischman, M. Nenadovic and G. Garcia-Lopez, "Synthesizing theories of natural resource management and governance," *Global Environmental Change,* vol. 39, pp. 45-56, 2016.

[29] Centers for Disease Control and Prevention, "Framework for program evaluation in public health," *MMWR,* vol. 48, no. RR-11, pp. 1-40, 1999.

[30] Ministry of Health and Social Welfare, "Health Sector Strategic Plan (HSSP IV) - July 2015 to June 2020," United Republic of Tanzania; Dar Es Salaam, 2015.

[31] M. Aanestad, M. Grisot, O. Hanseth and P. Vassilakopoulou, Information Infrastructures within European Health Care, International Publishing AG, 2017.