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USER-CENTRIC EVALUATION OF HOME-BASED TELEMEDICINE SYSTEMS FOR HUMAN RESOURCE MANAGEMENT

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Abstract
Telemedicine, enabled by telecommunications technology, overcomes geographical barriers to offer healthcare access. Real-time telemedicine involves synchronous interaction between healthcare providers and patients. It encompasses clinic- or hospital-based settings and home-based care. Clinic- or hospital-based telemedicine aids underserved areas by connecting with specialists remotely. Home-based telemedicine serves non-physical clinical visits, like behavioral health and counseling. Telemedicine's efficacy is demonstrated in reduced costs, improved access, and patient satisfaction. Barriers include costs, network issues, and system design gaps. Emerging technologies are enhancing home-based video telemedicine for managing chronic conditions. Widespread adoption is noted in dentistry, ophthalmology, dermatology, and mental health care. Technological advancements improve telemedicine's feasibility and affordability, thereby enhancing healthcare quality. Nonetheless, barriers remain, including usability and cost concerns. This study examines the usability of four home-based telemedicine platforms, employing task performance metrics and subjective evaluations to address existing gaps.

Keywords: Telemedicine, real-time telemedicine, home-based telemedicine, healthcare access, patient satisfaction, technology barriers.

1. Introduction

Telemedicine is the use of telecommunications technology to provide access to healthcare when geographical barriers make conventional consultation impractical. Real-time telemedicine entails a healthcare professional interacting with a patient or another care provider synchronously. Real-time telemedicine can be generally classified into clinic- or hospital-based telemedicine, and home-based telemedicine. Clinic- or hospital-based telemedicine entails connecting two endpoints that both reside in the clinic or hospital setting. This allows rural or underserved clinics or hospitals to provide their patients access to specialists not available in-person. Realtime hospital-based telemedicine allows a Neurologist from a large medical center to assess a patient in a rural hospital. Homebased telemedicine allows a healthcare professional to remotely connect with and provide care to a patient in the home (or elsewhere).Home-based telemedicine is often used for clinical visits that do not require physical presence such as behavioral health, counseling, follow up, result reporting, and patient education. Telemedicine has gained significant support in recent years as an acceptable care methodology, with effective utilization in many clinical domains. Telemedicine has been shown to significantly reduce costs and travel burden, while increasing access to health care, particularly to rural and underserved areas. Moreover, the results from a study conducted by Agha et al. (2009) to compare telemedicine consultation and inpatient consultation suggests that patients were equally satisfied with telemedicine and in-patient consultation in terms of physician's physical competence and interpersonal skill. In addition, the patients were more satisfied with telemedicine over in-patient in terms of convenience. A national survey conducted by American Wells revealed that nearly two-thirds of patients would be willing to meet with their doctor by telemedicine. With the precipitous decline in costs of technical capabilities, and its greater availability, telemedicine is quickly establishing itself as an acceptable care delivery model to augment the traditional delivery approaches.

A few barriers from a care-receiver perspective that prevent the adoption of telemedicine include the cost, network connectivity issues, and other technological issues while interacting with the system (Board on Health Care Services & Institute of Medicine (2012)). In addition, Waterson (2014) observed that there is a gap between the system design and the healthcare system, while summarizing the results of use of Health Information Technologies (HIT). This gap results in systems being used erroneously and prevents the adoption of technologies by healthcare experts. However, telemedicine technologies are becoming widely available in the marketplace and costs of telehealth technologies are dropping (Board on Health Care Services & Institute of Medicine (2012)). More recently, care providers are increasingly using homebased video telemedicine systems to manage chronic conditions such as hypertension and diabetes, age related issues and other health conditions that make it difficult for patients to travel to a hospital from a remote location .Care providers use two-way interactive video chat facilities to converse with patients, and determine whether the patient needs to be consulted face-to-face or not. Results of a recent study investigating the usability of FaceTime video conferencing for diabetes care suggests that 65% of 34 participants were satisfied with FaceTime visit. A patient living in rural area can be connected to a remote specialist with the help of technology,avoiding travel to the care provider. Widespread application of telemedicine can also be seen in dentistry, ophthalmology, dermatology and mental health care. Because of rapid advancements in technology, the implementation and management of telemedicine is becoming easier and more affordable, as evidenced by recent reduction in hospitalizations, readmissions, duration of stay, and costs for chronic disease management. The availability of better health-care at lower costs in turn quickens the technological advancement. A recent study conducted by Gardner et al. (2015) to understand patient perceptions of the feasibility and viability of video-based consultation from home, and their willingness to accept this type of care indicated that most patients were willing to accept video consultation from home. The authors pointed out several barriers that need to be addressed to facilitate a broader adoption of telemedicine technology, which included the usability and reduced cost for usage. The results of this study also suggest the need to evaluate available telemedicine solutions within the context specific needs of the users of these technologies for user acceptance and real-world applicability.

Limited research is conducted in evaluating the usability of such tools from a homebased video telemedicine system perspective has been conducted. To address this situation, this study investigates the usability issues associated with four home-based telemedicine software platforms using task performance metrics, and subjective measures (Agnisarman et al., 2017).

1.1. Selection of telemedicine systems

Eight software (Adobe Connect, Cisco WebEx, Doxy.me, Polycom,Skype, Vidyo and VSee) were identified as potential candidates from the preliminary review. Subsequently, detailed analysis of the features of each of the software and its primary use case was conducted, followed by feedback from care providers. The care providers suggested that while Adobe Connect, Skype and Cisco WebEx could be used to deliver video-based telemedicine; they did not meet the initial criteria or were not typically used to deliver telemedicine. The selected final telemedicine tools and brief descriptions of each are as follows.

Doxy.me. Doxy.me (https://doxy.me/) is a free telemedicine platform designed specifically for healthcare. Doctors can create personalized waiting rooms from which they can send invitation links. The patient is directed to the Doxy.me welcome screen where he/she enters his/her name. Then the patient checks into the waiting room. The self-view is located at the top right and a chat box at the bottom right of the patient screen. Toggle audio and video, full-screen, and end the call buttons are located below an enlarged doctor's video

Vidyo. Vidyo (http://www.vidyo.com/) is one of the leading telemedicine video conferencing software solutions. With Vidyo, the doctor emails an invite to the patient, who then clicks on the link provided to download a plug-in for VidyoWeb. The patient can check-in to doctor's waiting room by entering his/her name. The tool bar on the left shows the conference participants as well as provides an option to share views and applications. The patients can see the doctor's video as well as themselves in a small self-view box, which they turn off if they choose. In addition, they can change the layout of the screen. The tool bar below the doctor's video includes mute/unmute camera, microphone and speaker buttons, speaker volume control, a full screen button, and a disconnect button.

VSee. VSee (https://vsee.com/) is a video conferencing tool enables a doctor to email an invitation link to a patient who then creates a free account and installs the desktop VSee application. This study used the Pro version of VSee. Upon logging into a VSee account, a quick startup guide appears. There are separate windows for self-view, doctor's video, chat box, and contacts, with the microphone and camera settings being found on self-viewwindow.

Polycom. Polycom (http://www.polycom.com/) provides voice and video services for remote conferencing and collaboration. Polycom traditionally provides hardware-based telemedicine solutions, this product is the lightweight solution they provide for home-based care. The doctor emails an invitation from his Polycom account to a patient, who, on clicking on the link provided, is directed to a web page where he/she selects the device and system.

Upon making the appropriate selection and entering his/her name, the patient checks into the doctor's waiting room. The patient's screen has a self-view option on the left, the participant list on the right and the doctor's video in the middle. There are mute/unmute microphone and speaker buttons and a leave conference button below the doctor's video.

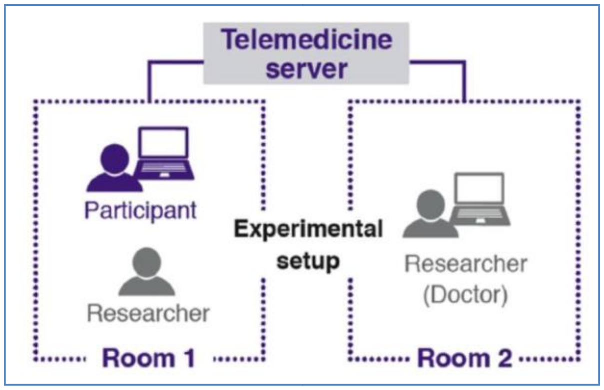

Fig. 1. Experimental setup

2. Results

Telemedicine has the potential to mitigate geographic barriers to quality medical care. While much research is available on the application of telemedicine in healthcare and patient management, the number of studies focused on the usability aspects of these platforms is limited, a concern because any barriers need to be identified and addressed for the successful implementation of telemedicine . To address this need, this study evaluated the usability of four telemedicine software platforms - Doxy.me, Vidyo, VSee and Polycom. Many insights into the different phases of a telemedicine session were gained through this evaluation (Bashshur et al., 2011).

2.1. Performance

The average task time was calculated from when the participant opened the invitation mail to when he/she hung up the call.Total task completion is divided into two components:time taken to initiate the telemedicine session and time taken to complete the consultation.

a) Initiation: The average time taken to initiate the telemedicine session was calculated from when the participant opened the invitation mail to when he/she completed the check in process.

b) Telemedicine session: The average time taken to complete the telemedicine consultation was calculated from when the doctor initiated the call to when the participant hung up the call.

The results showed significant differences in the average time taken to complete the telemedicine session, as shown in Fig. 2.

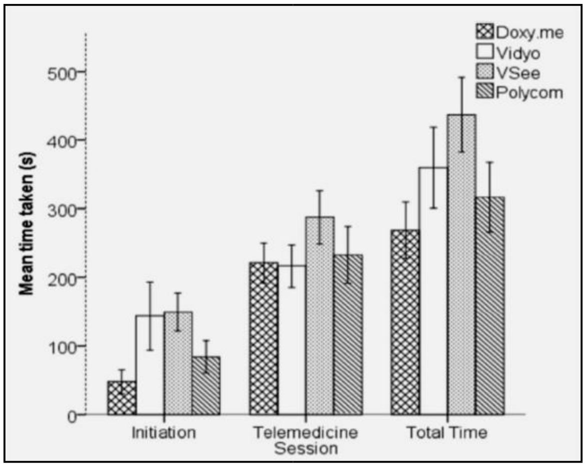

Fig. 2. Task completion time.

2.2. System usability

The responses to the Quality Computer System Usability Questionnaire (CSUQ) evaluated four metrics: overall satisfaction, system usefulness, information quality, and interface quality (Lewis, 1995). Figs. 3,4.

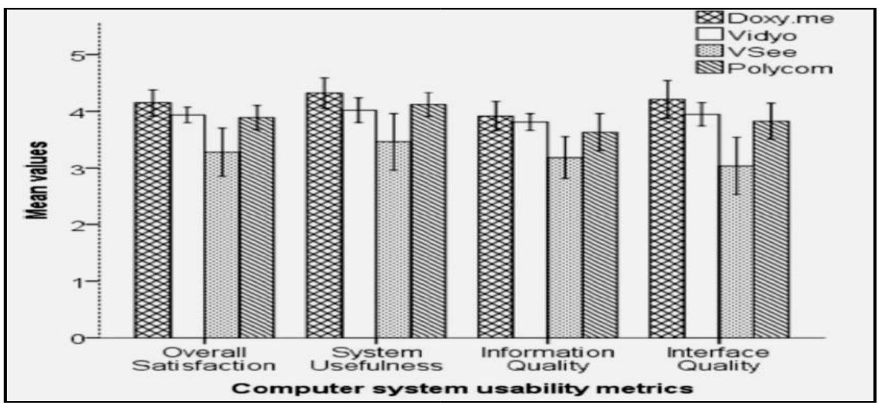

Fig. 3. Computer system usability questionnaire scores.

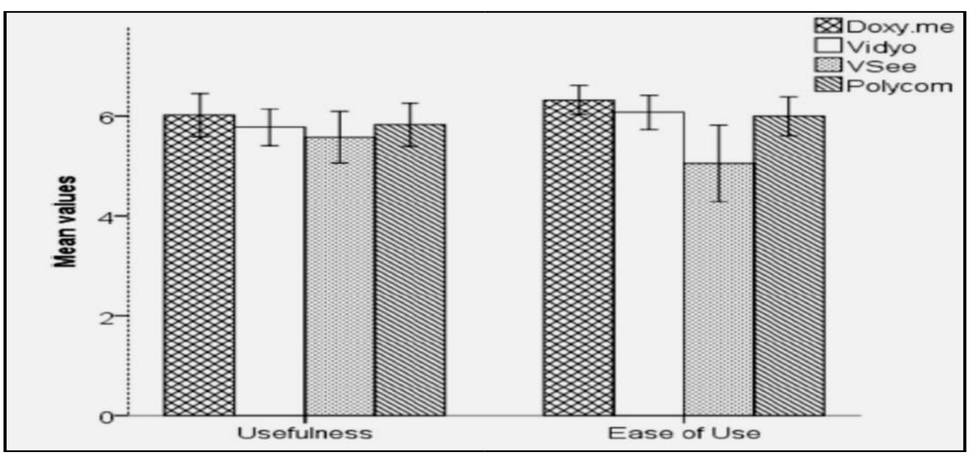

Fig. 4. Perceived usefulness and ease of use.

2.3. Preference

Preference data were obtained through a ranking scale, with a lower score indicating greater preference. The analysis of these data indicated significant differences for the preference of a telemedicine system The comments received from the participants during the retrospective think-aloud sessions are shown in Table 1.

Table 1. Most frequent comments received from the participants during the retrospective think-aloud sessions.

		Comments
Initiating the session	Doxy.me	*"It is frustrating that the system is not providing clear instructions to share my camera and microphone"*
		"I really like the 'click link and start session' aspect of Doxy.me"
	Vidyo	*"There are multiple links on the invitation email. I am confused on which link I should click."*
		"The instructions on this invite is confusing."
		"The invitation email is confusing."
		"I liked the aspect that I did not have to create an account."
		"I really don't know if the doctor is online."
	VSee	*"I did not realize that I was creating an account."*
		"I did not know what my password was; I just typed my email password."
		"The invitation email had clear instructions."
		"The checkin process is cumbersome."
		"The interface looks good; however better instructions are required prior to logging into the application."
	Polycom	*"I see multiple check-in options on the welcome screen. I am really confused which link should I be clicking"*
		"I love the welcome message and the music played by the system while I am waiting for the doctor to arrive"
		"Thank God! No need to install a software"
During the session	Doxy.me	*"Simple and clean interface"*
		"A quick tutorial on the actions that can be performed on the system would be helpful"
	Vidyo	*"Having a provision for chat could improve the system."*
		"Small pop-up boxes showing the functions of icons could improve the information quality of the system."
	VSee	*"I really like the option to chat."*
		"I wish I could do a full screen option on the system"
		"The system has four windows. It's confusing."
		"I am new to this system. A quick tutorial could help people like me who are not familiar with video chat systems."
	Polycom	*"The video quality was poor."*
		"The self-view window was not active. I initially that the system did not have an option for self-viewing."
		"I would really love to use a chat feature for this system."
Concluding the session	Doxy.me	*"The full screen mode is on even after ending the call. It's a bit confusing"*
		"I really like the tool tips when I hover over the buttons."
	Vidyo	*"I closed the browser tab to conclude the session. I am not sure if that is the right way to end the session."*
		"The icons for the buttons are confusing."
	VSee	*"The logout button of VSee is not visible. I am not sure how I can logout of the session."*
	Polycom	*"The end button of Polycom is clearly marked."*

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2.4. Gaps in current platforms many participants liked the chat facility supported by both VSee and Doxy.me, commenting that typing values into a chat box helped avoid ambiguity. The absence of this feature in Vidyo and Polycom was cited as a drawback.

The analysis of the preference data indicated that the participants preferred Doxy.me over Polycom, and Polycom over Vidyo and VSee, primarily because these two did not require the installation of plug-ins or an application. The overall satisfaction score was significantly low for VSee compared to Doxy.me, Vidyo and Polycom.

Three of the four platforms led to comparable satisfaction with variations in subdomains tested across platforms. The cumbersome session initiation phase, poor interface quality, and poor information quality associated with the platforms could have led to lower levels of user satisfaction. Avoiding account creation and the downloading and installation of applications and associated plugins could make the telemedicine session initiation phase easier.

The findings from this study could potentially help software developers address the usability and cognitive issues associated with telemedicine systems, resulting in a more user-friendly version of telemedicine systems. Technological systems need to be designed to serve the needs of people across different population and socioeconomic background to promote the adoption (Thompson et al., 2016).

2.5. Synthesis of user needs

Below are the user needs identified for "last mile" telemedicine programs that serve communities that have poor connectivity and almost no access to healthcare services. The user groups identified are CHWs, remote doctors, and system administrators or project managers.Patients are not considered a core user, as they have no direct interaction with the technology, but are an important stakeholder. The system needs to: ● Capture and store high quality clinical information longitudinally in an electronic health record

- Task-shift clinical processes to health workers in the field who are interacting with the patient
- Be portable, mobile, robust and low cost
- Be intuitive and easy to use for a user with low technical literacy
- Communicate information in a low bandwidth environment with limited and unreliable connectivity
- Provide access to patient information from multiple locations
- Require low capital investment in technology infrastructure and low power requirements
- Interface with other information systems such as laboratory, billing, pharmacy or inventory management
- Interface with point of care diagnostic devices
- Collect, report and present data for monitoring and evaluation including programmatic, financial and clinical
- Be easily customizable for various use cases and modular
- Have a high level of support by a technical team, organization or community of users

2.6. Intelehealth system design

They built and integrated components of the system using existing and widely used open source tools, where available. The system consists of an Android client that can be rapidly customized to handle complex clinical and data collection workflows. The client communicates with a cloud-based EHR system, OpenMRS. The system architecture is shown in Figure 5.

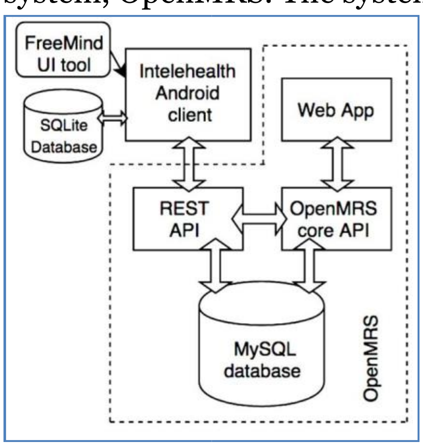

Fig. 5. In telehealth architecture diagram

In tele health works on basic mobile devices using a mobile 2G or 3G data connection so that it can operate in the remotest of settings. The protocol in JSON form allows the app to only transmit the data that was selected for that specific patient, thereby reducing the amount of bandwidth needed to transmit the data. In low bandwidth settings, this is extremely important. All visit information as text only can be transmitted using 18 kilobytes. In addition, we are developing a module that can transfer this data over SMS in the absence of a reliable internet connection.

Using the OpenMRS web client, the remote doctors can review patient medical records and collected health information, prescribe medications, give medical advice, order additional tests, and refer patients. OpenMRS is an open source enterprise electronic health record platform widely used in LMICs and is supported by a large implementer and developer community. The OpenMRS server has a core MySQL database with a robust data model for longitudinal management of patient data. The Intelehealth Android client communicates with the OpenMRS server through a RESTful API. Several other mobile & web clients have successfully interfaced with OpenMRS such as Sana, ODK, CommCare, OpenSRP and Bahmni through its RESTful API. OpenMRS has a modular architecture, which allows for customizations to how data is managed and presented. We developed a custom OpenMRS module for the doctor's UI. This UI is a web application allows doctors to easily view the patient information. Since the doctor's UI with the system is a web app, this allows for the OpenMRS server to be hosted in the cloud so that patient information can be accessed via the web app from any location. The web app also serves as the interface for system administrators to generate and view reports. OpenMRS allows for interoperability through the use of data standards like ICD 10, SNOMED, LOINC, etc. It also has pre-existing modules for integration with other common platforms such as DHIS2. Thus, there were several advantages to choosing OpenMRS as the server side application and the patient data repository.

3. Conclusion

In tele health is a modular, customizable open source platform that can enable health systems to deliver comprehensive primary health care, or implement selected protocols in a task shifted environment, where lesser skilled health workers can connect patients to remote doctors for delivery of evidence based primary health care. This is a preliminary framework and has been designed by following a user-centric design methodology. Further field validation of the platform is needed before its effectiveness in delivering comprehensive care can be fully concluded. We will begin testing the Intelehealth platform at field sites in the upcoming months (Goel et al., 2017).

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