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Human Factors Considerations in Designing Home-Based Video Telemedicine Systems for the Geriatric Population

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HUMAN FACTORS CONSIDERATIONS IN DESIGNING HOME-BASED VIDEO TELEMEDICINE SYSTEMS FOR THE GERIATRIC POPULATION

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by
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ABSTRACT

Telemedicine is the process of providing healthcare services when large distances separate the patient and the doctor, with the use of communication technology. Telemedicine serves as a substitute to in-person hospital visits and in large, reduces the need to travel and wait in line to visit the doctor. It is predicted to help the geriatric population in managing their healthcare requirements. In order for telemedicine to effectively help the older population, it is essential to understand their needs and issues in telemedicine systems. A study with 40 participants was conducted to understand the usability issues of telemedicine systems with the geriatric population. Four telemedicine video platforms 1) Doxy.me, 2) Polycom, 3) Vidyo and 4) VSee, were used to understand these issues using a between-subject experimental design. Participants completed a demographic survey, followed by a telemedicine session. This was followed by a retrospective think-aloud discussion session to understand their issues and needs concluding with a post-test survey. This survey included general questions about using the system followed by NASA-TLX workload measure and IBM-Computer System Usability Questionnaire (IBM-CSUQ). Some of the issues identified included lengthy email invitation with multiple web links, application download, registration and issues relating to icons used. A Cognitive Task Analysis (CTA) is a method for understanding the cognitive or mental demands involved in performing a task. A Cognitive Task Analysis was conducted for each platform to help identify potential cognitive issues when interacting with telemedicine systems. These solutions include providing a single necessary link in the email, eliminating the necessity to download and register, and,

contrast, placement and appropriate labels for icons. As suggested by the participants, detailed step-wise instructions on navigating through a session will also be provided. Future work in this area would be to develop such a system, which theoretically, will increase the efficiency in using telemedicine systems

DEDICATION

This work is dedicated to my parents, Dr. N Narasimha and Mrs. Savitha Narasimha. It is also dedicated to all the study participants who helped me learn much more than just the research matter.

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CHAPTER ONE

INTRODUCTION

Telemedicine, which is the exchange of medical information between locations through the use of electronic communication devices, is primarily used to improve healthcare services. Its most significant feature, the effective use of communication technology, allows it to function as a surrogate to in-person meetings (Bashshur, Reardon, & Shannon, 2000), thus providing diagnosis, pretreatment and/or post-treatment to medical issues comparable to the conventional face-to-face method of medical practice. (Sene, Kamsu-Foguem, & Rumeau, 2015) The first reference to telemedicine, albeit primitive, was made in 1897 in a magazine article reporting the use of a telephone in a home setting in lieu of personal visits to the doctor. (Lustig et al., 2012) Another early application of telemedicine was seen during NASA's first manned space mission when vitals were collected regularly from the astronauts to address the concerns of physiologists regarding the effects of zero gravity on the human body. (Bashshur et al., 2000) Telemedicine today involves delivering healthcare through laptops, tablets, smartphones and other such telecommunication devices. (Koch, 2006; Matusitz & Breen, 2007) It also includes private consultations with experts at distant hospitals and clinics (Izquierdo et al., 2003; Koch, 2006; Lustig et al., 2012) to access medical and pharmaceutical information.

Real-time telemedicine is classified into hospital-based and home-based telemedicine. (Coelho, 2011; Lustig & Others, 2012) Hospital-based telemedicine takes place in the same hospital or clinical setting and connects two care providers. Hospital based telemedicine is extensively used in Intensive Care Units (ICU) and stroke care. Home-based telemedicine connects a patient from the comfort of their homes with a medical specialist. This system, similar to general telemedicine, also relies on the use of easily available and inexpensive technology such as smartphones, tablets and personal computers for providing medical advice. (Koch, 2006)

One area where telemedicine may prove to be highly effective is in providing medical care to the older people. (Merrell, 2015) It is predicted that the geriatric group may soon account for 20% of the population; however, minimal research has been conducted on how effectively care can be delivered to the aging population. (Kang et al., 2010) Geriatrics, the branch of medicine focusing on health issues among the older people, may find telemedicine an appropriate means for addressing the issues of this population. One potential advantage of telemedicine is that it eliminates the travel necessary for more conventional treatment. This travel involved in conventional medical practice is expensive both in terms of personnel and finances. (Merrell, 2015) In addition, there is also a shortage of medical staff to handle the issues of the older population (Merrell & Doarn, 2015), compounded in rural areas by the cost of employing a full-time geriatrician which may be impractical because of the reduced caseload. (Brignell, Wootton, & Gray, 2007) These issues related to the healthcare of the geriatric population may be addressed by telemedicine.

Previously conducted research regarding the use of telemedicine to geriatric medical issues suggests a wide variety of applications, including providing long-term care for chronic diseases, medical access to the older people in the comfort of their homes, monitoring of vital signs and behavior, and increased access to physicians and other healthcare professionals in nursing homes. (Merrell, 2015) More importantly, the medical advice provided through telemedicine has been of good quality, resulting in improved patient satisfaction. In addition, the use of telephone consultation and video conferencing in geriatrics has been found to be cost-effective. (Jennett et al., 2003)

Telemedicine has been seen to be beneficial to the geriatric population in providing peer support, healthcare access in rural areas, reduced costs and reduction in transport requirements and also in improving functional independence. (Stronge, Rogers, & Fisk, 2007) However, usability of these systems with the geriatric population must be addressed. While the technology implemented is readily available and widely used, the geriatric population may not be as able to navigate and use it as well as the younger generations. For example, understanding technology-related commands provided by a healthcare professional during a session may be problematic to users with minimal experience and familiarity with technology. Further, the usability of telemedicine by the older population may also be affected by health-related issues, especially because system designers usually do not consider this age group to be potential users of a system and, therefore, focus little attention on the problems faced by them. (Demiris, Finkelstein, & Speedie, 2001) However, the overall usability of telemedicine systems is important in creating a positive attitude towards the use of technology in general and in the increased adoption of these systems specifically. (Hu, Chau, Liu Sheng, & Tam, 1999)

A detailed literature review led to an understanding of the current state of the usability of telemedicine systems and also provided insight on possible areas that require further attention. Extrapolating from previous studies, this research study aims to focus exclusively on the display related issues in home-based video telemedicine systems when used by the geriatric population. This study will investigate in detail, the aspects of a telemedicine session that are obstacles to the geriatric population. In order to understand these issues, the study will focus on three parts of a telemedicine session, namely – initiation (log in), video call session and session end (end call) and understand issues at each stage.

This thesis consists of 4 chapters. Chapter 1, the introduction, is followed by Chapter 2, a literature review, aims to understand the research that is presently in place investigating the usability of telemedicine systems. Chapter 3 outlines the experimental method used in conducting a pilot study and the results obtained. Following this, Chapter 4 which describes the methodology developed to carry out a complete study based on the initial pilot study. It will aim to evaluate the usability issues with the telemedicine systems and to develop guidelines for software designers to design user-friendly telemedicine systems.

CHAPTER TWO

A REVIEW OF THE USABILITY STUDIES WITH GERIATRIC POPULATION

This chapter reviews the usability studies conducted in a geriatric telemedicine setting. More specifically, it reviews articles published from the year 2000 until July 2016 with the goal of understanding 1) the characteristics of the usability-related studies conducted with geriatric population, 2) the aspects of usability explored in these manuscripts and the instruments used to measure them, 3) the data analysis methods used, 4) the impact of the usability of geriatric telemedicine technology on the user population, 5) usability challenges associated with telemedicine platforms, and 6) the limitations observed.

Materials and Methods

Institutional Review and Human Subject Determination

This study was exempt from approval by Clemson University's Institutional Review Board since it did not involve active human subject research. No individual patients participated in this study.

Inclusion and Exclusion Criteria

Only articles investigating usability factors in terms of telemedicine and geriatrics published in peer-reviewed publications between the years 2000 and July 2016 were considered for this review. However, one paper written by Couturier et al.(Couturier et al., 1998), obtained through the reference section of a paper met the inclusion criteria, and was included in this review. Other criteria included the use of a pilot study with the participants in the geriatric age group. In addition, the study had to include usability-related data from the perspective of the patient, not from the perspectives of the doctor or the care-giver. Another criterion important for inclusion was the requirement of a direct communication between the doctor and the patient.

Studies using such communication devices as Electronic Medical Records (EMR) and self-measurement of vitals and medication adherence were not included in this review. Usability studies on peripheral medical devices used as part of telemedicine, and general health monitoring using web-based applications which did not consist of care-provider and patient communications were also excluded. Virtual reality based health training applications, literature reviews, posters and extended abstracts were excluded as were papers discussing problems of the geriatric population but not including results from a user research study.

Search Strategy

As part of a systematic search, the online citation index services PubMed and Web of Knowledge were searched using the keywords *telemedicine AND geriatrics*, *telemedicine AND usability*, and *telemedicine AND usability AND older people*. The terms *geriatrics* and *older people* were used to find articles on the use of telemedicine by older adults, and the term *usability* was used to include usability studies with the geriatric population. The initial search for this review found 197 papers on the Web of Knowledge and 100 papers from PubMed.

The titles and the abstracts of these 297 papers identified were screened to determine which met the inclusion criteria. This resulted in 62 papers that met the inclusion criteria, with another 12 papers being selected from the references listed in these articles. Content screening was then conducted on these 74 papers. It was found that although the mean age of the participants in several studies was in the geriatric range, the individual participants did not meet this age criterion. Other factors leading to exclusion were insufficient data regarding the usability of the telemedicine systems, no direct communication between care providers and patients, and telemedicine systems consisting of medical records and health monitoring with no consultations. Finally, a total of 16 papers were selected for this systematic literature review.

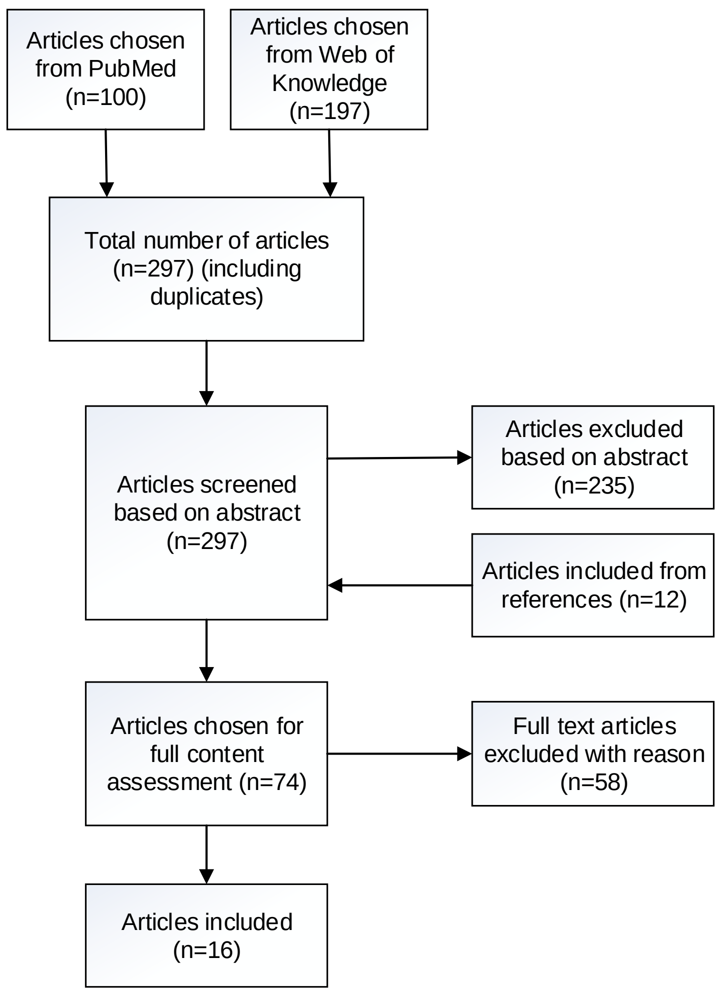

Figure 1. Study selection process

Data Extraction and Presentation

A table consisting of author name, year of publication, study objective(s), methods and a summary of findings was constructed to systematically document relevant information from these 16 publications. Table 1 (Appendix A) displays these data. More specific details regarding patient selection criteria and size, the data analysis methods, the technology used, and the impact of telemedicine are presented in the appropriate sections.

Results

Of the 16 studies identified for this review, 7 were conducted in the United States, 3 in China, and 1 in each Canada, the Netherlands, Germany, France, Denmark and Singapore. A representation of this classification is shown in Figure 2.

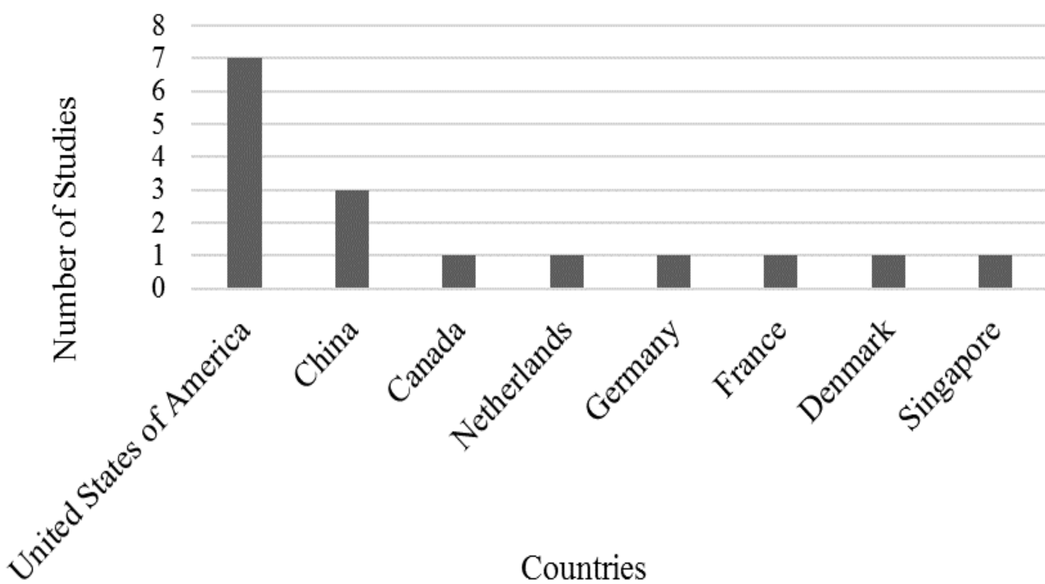

Figure 2. Number of telemedicine studies per country

The papers included in this review focused on a wide array of issues, with 75%,(Corcoran, Hui, & Woo, 2003; Couturier et al., 1998; Czaja, Lee, Arana, Nair, &

Sharit, 2014; Grosch, Weiner, Hynan, Shore, & Cullum, 2015; Hui, Woo, Hjelm, Zhang, & Tsui, 2001; Jasemian, 2008; Lamothe, Fortin, Labbé, Gagnon, & Messikh, 2006; Pallawala & Lun, 2001; Parker Oliver, Demiris, & Porock, 2005; Poon et al., 2005; Vermeersch, Sampsel, & Kleman, 2015; Wiborg, Widder, & Telemedicine in Stroke in Swabia Project, 2003) addressing such issues as acceptability, usability, reliability, feasibility, satisfaction, implementation of telemedicine and costs. The remaining 25%(Kobb, Nannette, Robert, & Sheri, 2003; Makai et al., 2014; Schofield et al., 2005; Shah et al., 2016) of the papers focused on specific objectives with patient satisfaction being one aspect. However, this difference in primary objectives resulted in the studies giving limited attention to patient usability criteria. Four papers, or 25%, (Kobb et al., 2003; Makai et al., 2014; Poon et al., 2005; Shah et al., 2016) involved studies using one control group and one intervention group, with the former seeing the doctor in person and the intervention group using telemedicine. Seven studies, or 43.75%, (Corcoran et al., 2003; Hui et al., 2001; Pallawala & Lun, 2001; Parker Oliver et al., 2005; Poon et al., 2005; Shah et al., 2016; Vermeersch et al., 2015) were based in elderly living centers; 6 papers, or 37.5%, (Czaja et al., 2014; Jasemian, 2008; Kobb et al., 2003; Lamothe et al., 2006; Makai et al., 2014; Schofield et al., 2005) were based in the homes of the elderly, and 18.75%, or 3 studies (Couturier et al., 1998; Grosch et al., 2015; Wiborg et al., 2003), took place in a hospital /clinical setting.

Patient Selection and Sample Size

Patient selection in 25% (4 studies) was based on age only; that is, participants had to be aged 65 years or older, while the remaining 75% had specific criteria for patient inclusion. The 4 studies (Hui et al., 2001; Pallawala & Lun, 2001; Shah et al., 2016; Vermeersch et al., 2015) with the general age criterion required the patients to be within the appropriate age limit and have the capacity to independently read and sign the consent form. Some of the criteria for participant selection in the remaining 12 papers included mild cognitive impairment and mild dementia (Poon et al., 2005) as well as geropsychiatry patients. (Grosch et al., 2015) Specific health conditions such as chronic systolic heart failure, (Schofield et al., 2005) severe cardiac insufficiency, hypertension or unstable diabetes, (Lamothe et al., 2006) at least a one-year history of blood pressure problems, (Czaja et al., 2014) patients with potential or active foot problems, (Corcoran et al., 2003) stroke patients, (Wiborg et al., 2003) geriatric orthopedic patients, (Couturier et al., 1998) and patients requiring multidisciplinary care (Makai et al. 2014) were criteria for participant selection in various studies. Other criteria included similarity in health issues, healthcare resource utilization and healthcare expenses, (Kobb et al., 2003) heart arrhythmia (Jasemian, 2008) and elderly living in a particular senior assisted living facility. (Parker Oliver et al., 2005)

In addition to these criteria, several studies conducted tests to determine the physical frailty and mental condition of the patients. The Cantonese Mini-Mental State Examination (Cantonese-MMSE), (Poon et al., 2005) the EASYcare-Two Step Older Person Screening, (Makai et al., 2014) the Mini-Mental State Examination (MMSE) and the Epidemiology Studies Depression Scale (CESD) (Czaja et al., 2014; Makai et al., 2014) were specific tests used for further screening of prospective participants.

The studies varied in their sample sizes, the number of participants ranging from 8 to 495. The average age for all the participants in all the studies was over 65; hence qualifying them to be included in this review. Table 2 lists the criteria used by each study for selecting its participants.

Telemedicine technology

The devices and equipment used in the practice of telemedicine varied among the studies reviewed here. The most widely used communication device for video conferencing was a computer, (Corcoran et al., 2003; Couturier et al., 1998; Makai et al., 2014; Pallawala & Lun, 2001; Poon et al., 2005) sometimes paired with a telephone to conduct the sessions. (Kobb et al., 2003; Lamothe et al., 2006; Shah et al., 2016) In addition, telephone calls were used by the nurse to contact patients when the vitals they uploaded were significantly different from their normal values. (Jasemian, 2008; Lamothe et al., 2006) Telephones were also used to interview patients upon completion of a baseline vital check and to review their electronic records. (Kobb et al., 2003; Shah et al., 2016) In addition, one study used videophones for research purposes. (Parker Oliver et al., 2005)

The study conducted by Vermeersch et al. (Vermeersch et al., 2015) incorporated a robot, specifically built for telemedicine, consisting of a laptop, cameras, a joystick for movement and a stethoscope attached. This telepresence robot was actively involved in the sessions as the patients used it to take various simple measurements ordered by the consulting doctor.

In two studies, (Czaja et al., 2014; Schofield et al., 2005) devices other than conventional communication modes were provided by the healthcare providers to help patients upload their vitals onto a website. The devices used for this purpose included Health Buddy by Health Hero Network, Inc. and LifeLink Monitoring based in Lake Katrine, New York.(Schofield et al., 2005) These in-home messaging devices transferred the data concerning the patient's vitals to a nurse who followed up with a telephone call if a problem was detected. In addition to Health Buddy, the study conducted by Czaja et al.(Czaja et al., 2014) also used American Telecare’s audio-video devices and IDEAL Life Telehealth System. A color television was also used for video output in two studies(Hui et al., 2001; Wiborg et al., 2003) and a Tanberg 1000 Video Conferencing System was used for patient and doctor communication in one study.(Grosch et al., 2015) Figure 3 represents the communication devices used categorized per 5-year period.

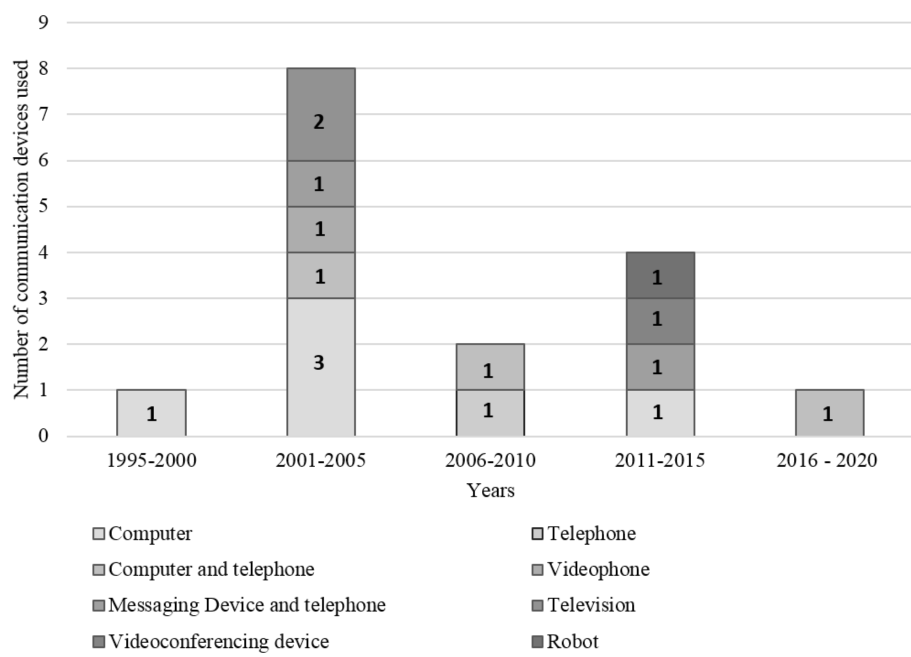

Figure 3. Communication devices used per five-year period

Peripheral devices were also incorporated with these devices. High resolution cameras were used in 31.25% to obtain a better view of the patient, (Couturier et al., 1998; Hui et al., 2001; Poon et al., 2005; Vermeersch et al., 2015; Wiborg et al., 2003) with one study using a 3Com webcam inbuilt in a laptop for patient monitoring, (Pallawala & Lun, 2001) and a document camera was used in another.(Corcoran et al., 2003) In addition to video cameras, some studies incorporated medical devices to measure blood pressure (Czaja et al., 2014; Jasemian, 2008; Schofield et al., 2005) and scales to measure body weight, (Czaja et al., 2014; Schofield et al., 2005) while others had a more elaborate setup including other medical testing devices such as a stethoscope (Vermeersch et al., 2015) and a sphygmomanometer and oximeter.(Lamothe et al., 2006)

To transfer the medical data from the patient to the medical professional, two studies (Grosch et al., 2015; Poon et al., 2005) used standard broadband connections; three studies (Corcoran et al., 2003; Hui et al., 2001; Wiborg et al., 2003) used ISDN connections; two used wireless data transfer; (Lamothe et al., 2006; Vermeersch et al., 2015) three studies (Czaja et al., 2014; Kobb et al., 2003; Parker Oliver et al., 2005) specified telephone line connections; 1 study used a standard GSM/GPRS connection (Jasemian, 2008) and 1 study an ADSL connection. (Pallawala & Lun, 2001) One within hospital teleconsultation study (Couturier et al., 1998) used a coaxial cable for video conferencing across rooms. Of the 16 studies included in this review, three (Makai et al., 2014; Schofield et al., 2005; Shah et al., 2016) did not mention the data transfer connections used, referring only to the website used for the data uploaded.

Websites were also used by care providers for obtaining patient information on a regular basis. One study (Makai et al., 2014) referred to the use of a self-developed portal, Zorg en Welzijns Informatie Portaal (ZWIP), an Online Health Community (OHC), which contained a secure messaging system and a shared Electronic Health Record. Messages shared via this portal were visible to others, and discussions could be initiated by a user. A professional could enter the discussion only with the consent of the user. Another study (Shah et al., 2016) investigated the impact of the team's Health-e-access Program for acute illness care. In this study, when a telemedicine consultation was requested, a clinical technician first collected and transferred the clinical history of the patient via an Electronic Medical Record Service, TeleAtrics, then initiated the consultation. Table 3 (Appendix A) lists the communication device used in each study.

Data Analysis Method

The papers reviewed here used a combination of both qualitative and quantitative data analysis methods, with the former primarily being for interview data, while the latter involved data obtained from Likert scale values and ratings for qualitative values such as satisfaction, reliability, confidence in the system and acceptance and for dependent variables such as the before and after effects of telemedicine. Three studies used qualitative data analysis, with the remaining using quantitative data analysis methods.

Qualitative analysis - In the study focusing on understanding the impact of home telehealth in terms of patients, providers and organizations, (Lamothe et al., 2006) data collected through interviews were recorded and compression techniques were applied. Notes made during the periodic meetings with patients were also analyzed to gain an understanding of the patient perspective of home telehealth. One study analyzed patient satisfaction surveys provided at 6-month intervals via custom-made interview questions, (Kobb et al., 2003) and exit interviews at the end of the teleconsultation were used to obtain feedback on patient satisfaction in another. (Grosch et al., 2015)

Quantitative analysis - In addition to a Likert scale for analyzing telemedicine characteristics, several other statistical methods were used, sometimes in combination with a Likert scale. The study conducted by Jasemian (Jasemian, 2008) used questionnaires to test the usability, reliability, freedom and mobility, and degree of confidence and trust in the system under study. To understand improvement before and after the telemedicine consultation, a within group paired sample t-test was used by Schofield et al. (Schofield et al., 2005) In conjunction with this, a signal ranked test to compute the mean number of hospital bed days of care before and after teleconsultation was also performed. In the test conducted by Shah et al., (Shah et al., 2016) baseline values for patients were measured using descriptive statistics along with a two sample *t* test, Chi-squared or Fisher's exact test. To study the impact of the use of telemedicine on Emergency Departments, Generalized Estimating Equations were used. A mixed design repeated measure analysis of variance (ANOVA) was used to test for differences between baseline time and the effects of telemedicine after 6 months along with a Mann-Whitney U test to measure patient satisfaction obtained through a questionnaire. (Czaja et al., 2014) Another study analyzed categorical data using a Chi Square test along with the Mann Whitney U test for analyzing ordinal data and the Student *t* test for normal data.

This was combined with a 5-point Likert scale test to analyze patient satisfaction. (Wiborg et al., 2003)

A few studies used both qualitative and quantitative data analysis. (Corcoran et al., 2003; Couturier et al., 1998; Czaja et al., 2014; Grosch et al., 2015; Lamothe et al., 2006; Pallawala & Lun, 2001; Parker Oliver et al., 2005; Vermeersch et al., 2015; Wiborg et al., 2003) Likert scale values were used to find the mean and standard deviation values for characteristics such as-reaction, satisfaction, effectiveness and usefulness-and written comments for each of the Likert scale questions were characterized as positive or negative. One study did not specify the data analysis method used. (Pallawala & Lun, 2001)

Impact of telemedicine

Five studies, or 31.25%, investigating patient satisfaction reported that the participants indicated high levels of satisfaction, (Couturier et al., 1998; Grosch et al., 2015; Hui et al., 2001; Kobb et al., 2003; Schofield et al., 2005) while a high level of acceptance for telemedicine was also found in 5 (31.25%) studies. (Corcoran et al., 2003; Couturier et al., 1998; Lamothe et al., 2006; Parker Oliver et al., 2005; Shah et al., 2016) In addition, 3 (18.75%) papers (Corcoran et al., 2003; Pallawala & Lun, 2001; Poon et al., 2005) determined that the participants found telemedicine to be more convenient than a regular visit to the doctor. Usability and effectiveness ratings (Vermeersch et al., 2015) in one study (6.25%) and convenience of telemedicine (Wiborg et al., 2003) in another were reported to have high ratings. Another study (Jasemian, 2008) reported that more than 50% of the participants reported high values for usability, reliability, privacy, and trust and confidence in the system.

Confidence in teleconsultation (Pallawala & Lun, 2001) and care coordination (Schofield et al., 2005) were found to receive high ratings by the participants involved in the studies. The technology was perceived to be easy-to-use by the participants, (Parker Oliver et al., 2005; Schofield et al., 2005) and patients indicated that they could monitor their health better (Czaja et al., 2014; Lamothe et al., 2006) and received better health-related information using telemedicine (Lamothe et al., 2006) than through traditional face-to-face consultations.

Results from two studies found that the number of Emergency Department visits declined due to the use of telemedicine, (Lamothe et al., 2006; Shah et al., 2016) and two studies (Hui et al., 2001; Wiborg et al., 2003) indicated that the cost of telemedicine was cheaper than its conventional alternative. However, one study found low rates of usage of a telemedicine portal, concluding that introducing new technology to the older population is not easy. (Makai et al., 2014) In addition, participants reported trouble seeing and hearing the doctor as well as a general lack of confidence in the system. (Hui et al., 2001)

The patients using telemedicine indicated an improved awareness of their health in addition to feeling that the technology helped them monitor their health. More specifically, results reported that patients saw telemedicine as convenient way to manage their healthcare. (Pallawala & Lun, 2001) Users also reported reduced privacy concerns and high confidence in these systems. (Jasemian, 2008) The presence of a nurse was attributed to higher confidence in navigating through the procedure. (Lamothe et al.,

2006) While an increase in the technological experience directly impacted the patients' attitudes towards technology, studies also showed that issues such as interference between videophones and hearing aids were reported. (Parker Oliver et al., 2005) Patients were also found to be ill-at-ease due to the presence and use of a camera in one study. (Couturier et al., 1998) A participant in another study complained about the inability to read the numbers on a videophone used for telemedicine purpose because of the color used. (Parker Oliver et al., 2005) However, this review found that limited research has been conducted focusing exclusively on the design of the telemedicine technology and how these factors impact geriatric user's reaction to telemedicine systems.

Discussion and Future Direction

Contrary to the common belief that older adults are reluctant to use technology, research has found that 65% of the geriatric population want to keep abreast of current advancements. (Pak & McLaughlin, 2010) However, for telemedicine systems to be usable and friendly for these older adults, there is a need to adopt a human-centered design approach in their development. (Czaja et al., 2014) The majority of studies included in this systematic review were conducted at a later stage in the telemedicine system design cycle, either at the end of the system design or after implementing the system. Future research should be conducted throughout the design process, specifically considering how age-related factors may affect the interaction of the elderly with telemedicine technology and, in turn, making the appropriate design changes. These problems may be in the areas of vision, hearing, cognition and motor skills, to name a few. (Stronge, Rogers, & Fisk, 2007)

Vision-related issues found in the aging population include problems in visual acuity, contrast sensitivity and visual search. Visual acuity refers to the resolution at which a person sees an object while contrast sensitivity is the ability to differentiate between light and dark areas of an object, and visual search involves the movement of the eyes in conjunction with the focus on the surrounding area when in search of a specific object. In telemedicine systems, these visual problems may manifest in older patients experiencing difficulty reading the buttons on a phone or laptop.(Parker Oliver et al., 2005)

Older adults also experience hearing issues involving problems with sound localization making it difficult to pinpoint the direction of a sound or difficulties in the perception of its loudness or in hearing the background noise indicating such issues as mechanical failure of devices. (Pak & McLaughlin, 2010) These sound-related difficulties should be considered in selecting devices for telemedicine as they should either include appropriate adjustments to accommodate the older population or alternative means should be provided to compensate for the hearing problems. It was found in the studies reviewed here that patients with hearing disabilities found it difficult to communicate using telemedicine equipment, and participants also reported interference between a videophone and the hearing aid in the study. (Parker Oliver et al., 2005) Such problems need to be addressed as these systems are being designed and prototyped.

An effective device or display screen is one that helps users easily navigate through a series of activities to achieve a final goal. The success of this process depends on cognitive ability, which, in older adults may be affected due to age, resulting in reduced working memory capacity, perceptual speed, reasoning ability and attention. Increased reliance on environmental support or on additional information concerning a specific task is also found in older adults. In addition, spatial ability, the skill to manipulate objects based on location required, for example when reading a map or a computer screen, also degrades with age, meaning the elderly may have issues with telemedicine. Bearing in mind the visual and cognitive constraints resulting from the onset of old age, a study to understand the needs of the elderly in telemedicine computer applications must be carried out. This would lead to a comprehensive list of problems faced by the geriatric population in using these applications. In turn, their requirements in such a system and design ideas to mitigate these issues could be formed.

Finally, a loss in motor skills and motor coordination in older adults also affects their ability to carry out tasks. (Stronge et al., 2007) Their response time and the time taken to complete a task are higher and their accuracy in doing these tasks are reduced with age, (Pak & McLaughlin, 2010) issues that should be considered in designing telemedicine systems. In addition to these factors, other suggestions for future research in this area are provided below.

Sample Size - Of the 16 research papers considered for this review, 8 cited sample size as a limitation of the study. Most of these involved sample sizes of fewer than 50 participants, with some being as low as 8. The remaining 8 studies used sample sizes ranging from 82 to 495 participants. One paper made no mention of the number of participants included in its study. (Pallawala & Lun, 2001) As these results suggest, there is a need for studies with larger sample sizes to explore telemedicine usability among the geriatric population.

Cost analysis - Although two studies(Hui et al., 2001; Wiborg et al., 2003) indicated that telemedicine was a cost-effective alternative to traditional in-person visits to the doctor, more studies are needed to validate this conclusion. In addition, it is important that future work investigate the impact of the equipment (high-end audio-video devices, basic smartphones) and the setting (hospitals, nursing homes) where telemedicine is used on its cost.

Absence of external help -- Patients explicitly reported feeling more comfortable using the telemedicine system in the presence of a nurse. (Lamothe et al., 2006) While this presence may have been reassuring leading to higher patient satisfaction in the study, circumstances may occur when a nurse is unavailable to provide this assistance. It is important to examine how people perform without this external help. This may lead to new perspectives as well as problems concerning the usability of telemedicine by the older population.

Accessibility - All studies included in this literature review were set in hospitals, elder living communities, nursing care or private homes. In all these settings, the patients had access to private audio-video devices or community equipment specified for general use, all of which were in place before the study was conducted. However, there is a need to study the availability of internet access and videoconferencing devices among the geriatric population in general and in rural areas specifically.

Others - Other areas for future work include the issues related to privacy in the exchange of medical records online, the level of participant trust associated with telemedicine systems and the availability of insurance coverage for these sessions. The security of data uploaded online is also an issue which may need further investigation.

Limitations

This systematic review is not without limitations. The search string was very specific and may not have captured all relevant articles. The lack of uniformity in the articles' descriptions of usability and the methodology employed in the studies may indicate that it is possible that articles meeting our inclusion criteria were overlooked and not included in this review. The exclusion of studies not published in English may limit the generalizability of our findings to the global effort to improve telemedicine usability evaluation.

Conclusion

This section reviews the research conducted on telemedicine systems as applicable to the geriatric population, focusing on its usability. While telemedicine has repeatedly been shown to be useful in obtaining medical information and advice, this review suggests a limited number of published studies describing scientifically valid and reproducible usability evaluations at various stages of telemedicine system development. To foster user acceptance of telemedicine technologies, it is important for healthcare users to have a positive attitude toward using such system. A key factor influencing user acceptance is the usability of the telemedicine system. It is critical for real-world applicability to situate telemedicine applications within the context-specific needs of the people benefiting from or otherwise affected by them. Limited research has been conducted evaluating the usability of such tools with geriatric patients. Studies with larger sample sizes and with a special focus on use of this technology by this population are needed. The geriatric population can benefit from this method of medical consultation and, hence, efforts must be directed towards understanding usability issues and addressing them to ensure effective use by the elderly. This is an increasingly important area of research as this population group continues to grow and medical costs increase.

CHAPTER THREE

METHOD

The review of the literature presented several areas in need of study and improvement in the use of telemedicine systems among the geriatric population. With a focus on understanding the design factors affecting the target population, an empirical study was designed to understand them.

Participants

This study involved 40 participants, 60 years and older (M= 67.1, SD=9.42), 13 males and 27 female participants, all with a basic knowledge of computers. This sample size was used based on the recommendations from the previous studies for conducting empirical usability research. (Bevan, 2003; Kapil Chalil Madathil & Greenstein, 2011; K. Chalil Madathil, Greenstein, Neyens, Juang, & Gramopadhye, 2013; Faulkner, 2003; Madathil et al., 2012; Madathil, Alapatt, & Greenstein, 2010; Virzi, 1992) Prior research shows that 5 users can detect 85% of interface issues and 20-40 can detect 95%. (Virzi, 1992) Participants were recruited through flyers, emails and word-of-mouth and were compensated with a $25 gift card.

Apparatus

The study used two 14-inch Dell Inspiron laptops with built-in web cameras running on Windows 7 operating systems as the primary means of communication. High speed wireless internet connections were used for the video calls and Logitech headphones for the audio input and speech. In addition, the participants were provided with a mouse. Mozilla Firefox was the browser used for the telemedicine systems under study and the screen recording software Camtasia recorded the patient's laptop screen. An audio recorder was used to record the discussions with the patients.

Experimental Design

The independent variable for this study was the telemedicine systems selected based on HIPAA compliance, video and audio capabilities, ease of accessibility through a computer with internet connectivity and lack of the need for peripheral equipment. While the telemedicine systems used by the Medical University of Carolina took precedence, the search of currently available platforms satisfying these criteria resulted in the selection of the four platforms listed below:

1. Doxy.me—This video conferencing platform designed specifically for medical consultation purposes begins with the patients receiving an email from the doctor. On entering their names, they are directed to a virtual waiting room. Options included in the video session are a microphone toggle, video toggle, full screen and chat box. Figure 4 shows the email, the login screen and the patient view of the video session using this platform.

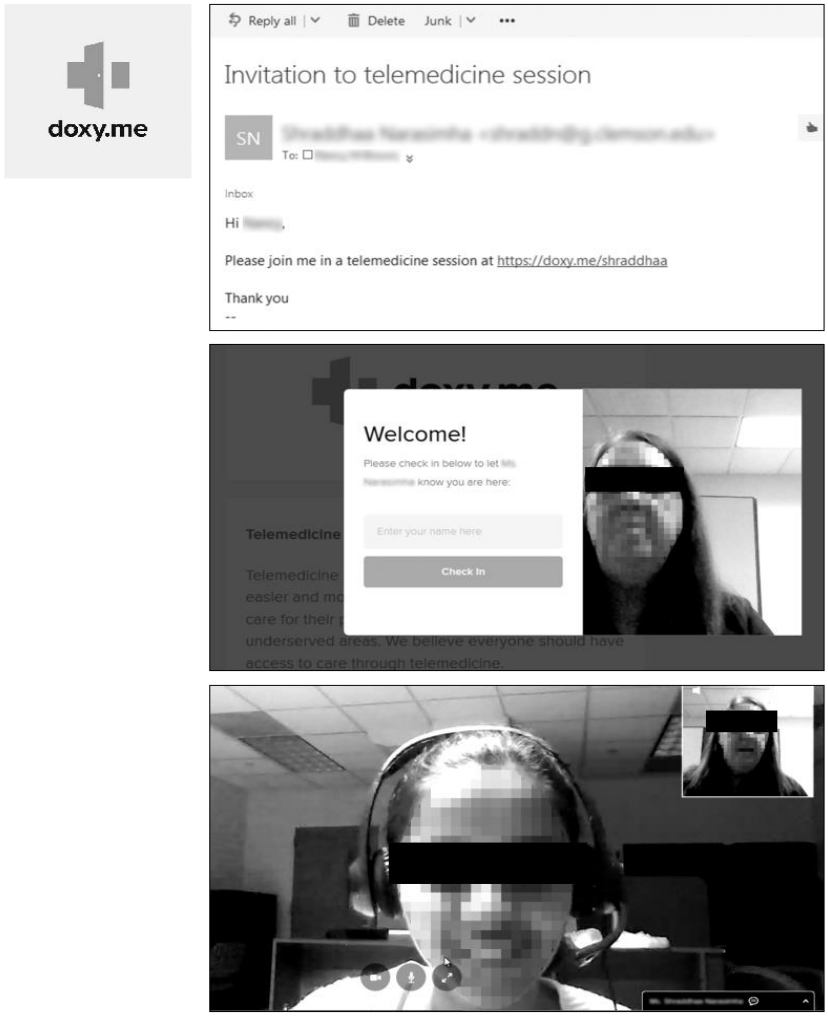

Figure 4. Email invitation, login screen and patient view during video session in Doxy.me

2. Polycom – While Polycom offers a wide variety of hardware and software video conferencing solutions, the product used here was a web-based video conferencing application. The care provider sends an email invitation containing a link which redirects the patients to the web application. They then choose either computer, video or telephone as the device for this session as well as either a browser or software application for accessing the web portal. The patient is directed to the doctor's waiting room and subsequently to the video call with a

microphone toggle, full screen and end call icons. The email invitation, login page and video call images for this platform are as shown Figure 5.

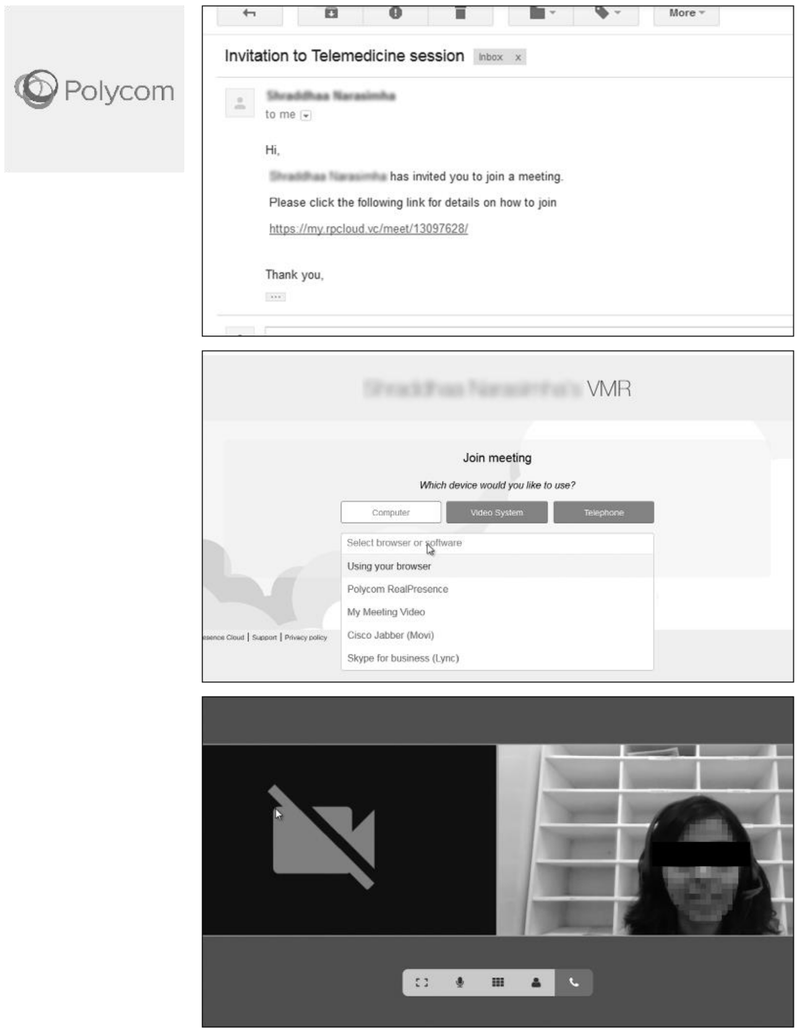

Figure 5. Email invitation, login screen and patient view during video session in Polycom

3. Vidyo – Vidyo is a video conferencing platform used extensively for telemedicine. An email including multiple web links is sent to the patient, who after clicking on the correct one is lead to a page with plugin download options and instructions. The installation of the plugin leads to a welcome page asking for the patient’s name. The subsequent video call consists of a microphone toggle,

video toggle, full screen and end call options. Figure 6 shows the email invitation, the login page and patient view in Vidyo.

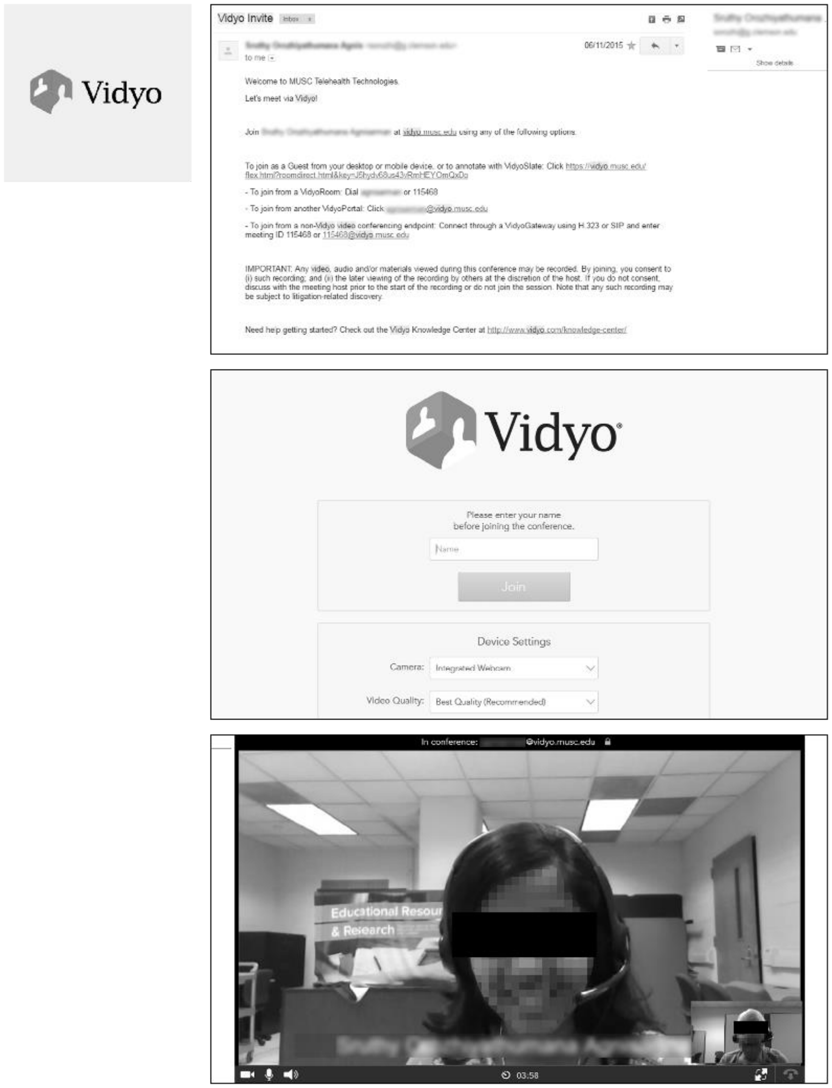

Figure 6. Email invitation, login screen and patient view during video session in Vidyo

4. VSee – For Vsee, a video conferencing platform, the doctor sends an email invitation that directs the patient to a new user registration page followed by a desktop application download option. This application requires the patient to login with a username and password. The video call includes the options of a

microphone toggle, video toggle, full screen, chat box and end call. The images of the email invitation, registration page and patient view during the video call are shown in Figures 7.

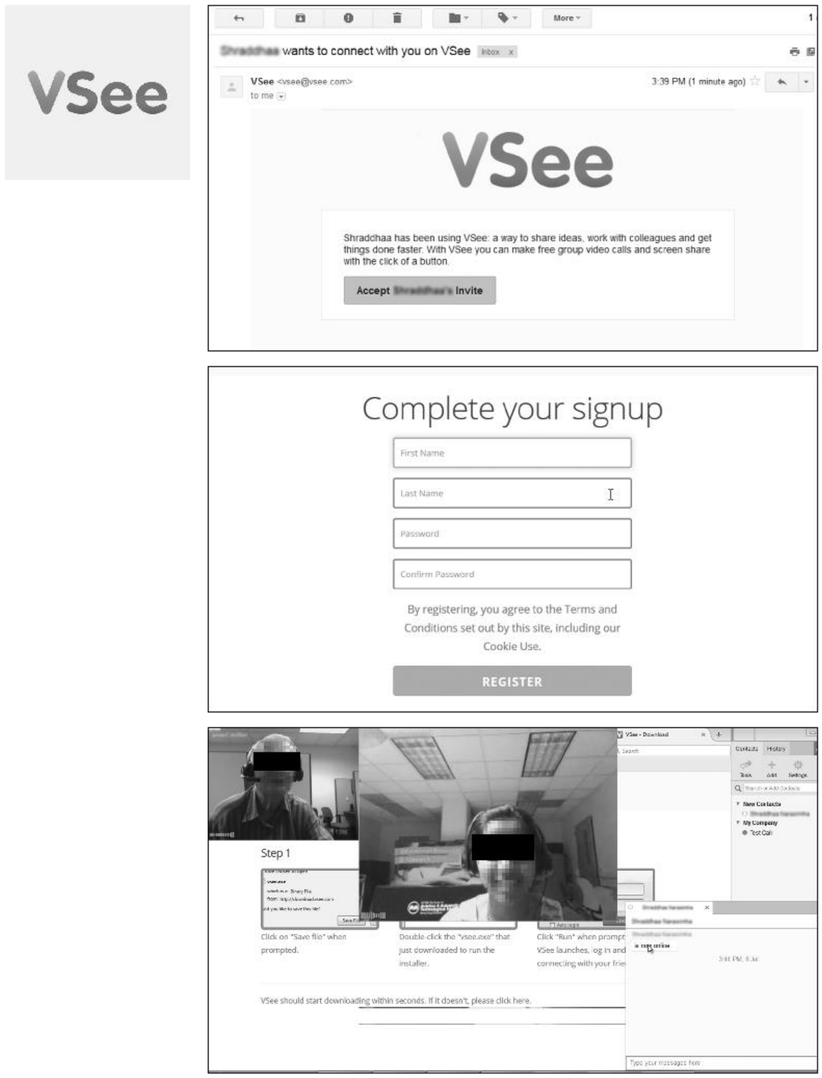

Figure 7. Email invitation, login screen and patient view during video session in VSee

Procedure

For this between subject study, each participant was randomly assigned to a telemedicine platform. On the day of the study, using a script, the researcher provided the participants with an overview of the study as well as the IRB-approved consent forms. After signing the consent, they were asked to complete a demographic survey asking for such data as age, race, and experience with computers. While the lead researcher set up the equipment in another room for the video call session, a second one remained with the participants to monitor the session, recording any errors made (Figure 8). However, this researcher did not provide explicit instructions on navigating through the video session nor complete tasks on behalf of the participant.

The lead researcher in the role of a doctor emailed an invitation to the participant (i.e., the patient) to join a video call. Following a script, the doctor then completed a video call with the patient involving the representative tasks of turn off/on the microphone, turn off/on the video (where applicable), full screen, enter blood pressure values in a chat box (where applicable) and finally end the call. The video call, which was recorded using a screen recording software, was followed by a retrospective think-out-loud session (Lewis, 1982) in which the participants discussed the issues they faced and the possible reason for them. Detailed notes were recorded by the researcher during this session. The IBM-Computer System Usability Questionnaire and the NASA-TLX workload measures were then completed by the participants. Each session lasted approximately an hour.

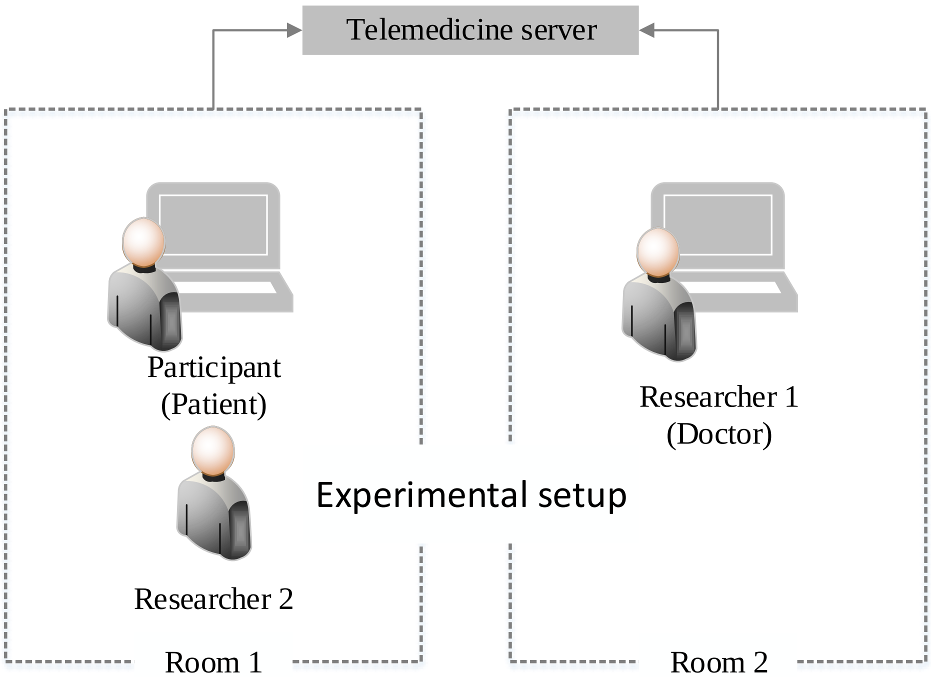

Figure 8. Experimental setup

Dependent Variables

The dependent variables for this study included the average time for task completion and the mean number of errors observed. In addition, ratings from the post-test satisfaction survey, the NASA-TLX workload measures (Hart & Staveland, 1988), and the system usability ratings from the IBM-CSUQ metrics (J. R. Lewis, 1995) were also considered as dependent variables for statistical analysis.

Analysis

IBM SPSS Statistics 23 was used for the statistical analysis. A one-way Analysis of Variance with 95% confidence interval was performed on the data obtained. The time taken, number of errors, NASA-TLX workload measures and IBM-CSUQ metrics were averaged across the telemedicine platforms. Post hoc LSD analysis was conducted to understand the locus of statistical difference.

CHAPTER 4

RESULTS

Demographic Data

Self-reported demographic data indicated that 35 of the participants were White/Caucasian, 2 African Americans and 1 each Hispanic, Asian and other races. Among the participants, 11, indicated they had a 4-year college degree, followed by 8 doctoral degrees, 6 each for Master's and 2-year college degrees, and 2 each for high school and professional degrees, the remaining 5 indicated some college. Of the participants, 39 indicated that they had used computers for at least 5 years, with 38 indicating daily internet usage.

Performance Measures

Mean completion time

The mean time for session completion was categorized as initiation time and video session time. The mean time for initiation was measured from opening the email invitation to entering the virtual waiting room, while the video session time was measured from when the video call began until the patient ended it. A one-way ANOVA was conducted to determine the time taken to complete the tasks for the various platforms.

As seen in Figure 9, the initiation times averaged across the platforms resulted in VSee (M=5.34, SD=2.58) requiring the longest time, followed by Polycom (M=3.40, SD=1.56), Vidyo (M=3.39, SD=1.26) and Doxy.me (M= 1.86, SD=1.1). Statistical significance was found for the four platforms, $F(3,36)=6.811$, $p=0.001$. The initiation time increased from Doxy.me (M= 1.86, SD=1.1) to VSee (M=5.34, SD=2.58), p<0.001, Polycom (M=3.40, SD=1.56), p=0.017 and Vsee (M=5.34, SD=2.58) and, Vidyo (M=3.39, SD=1.26) and VSee (M=5.34, SD=2.58) with p=0.016.

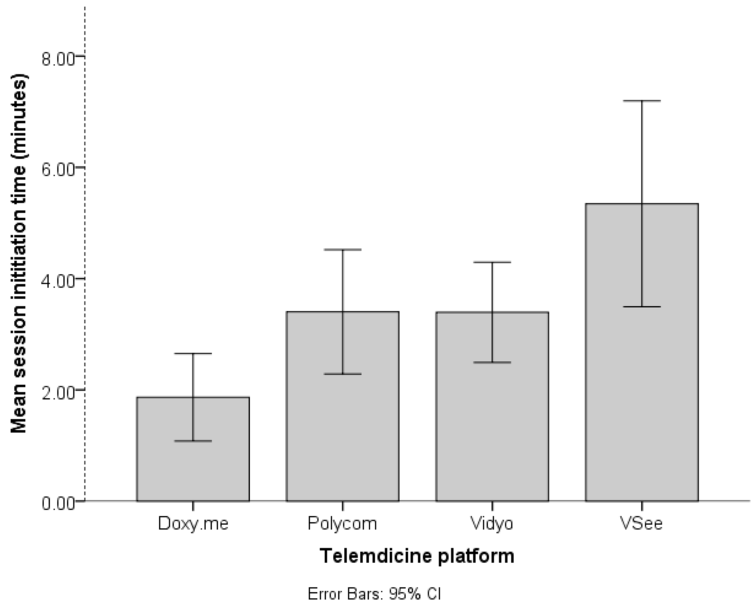

Figure 9. Mean session initiation time

Statistically significant differences were not present among the telemedicine platforms for session completion times for the four platforms, F(3,36)=0.486, p=0.694.

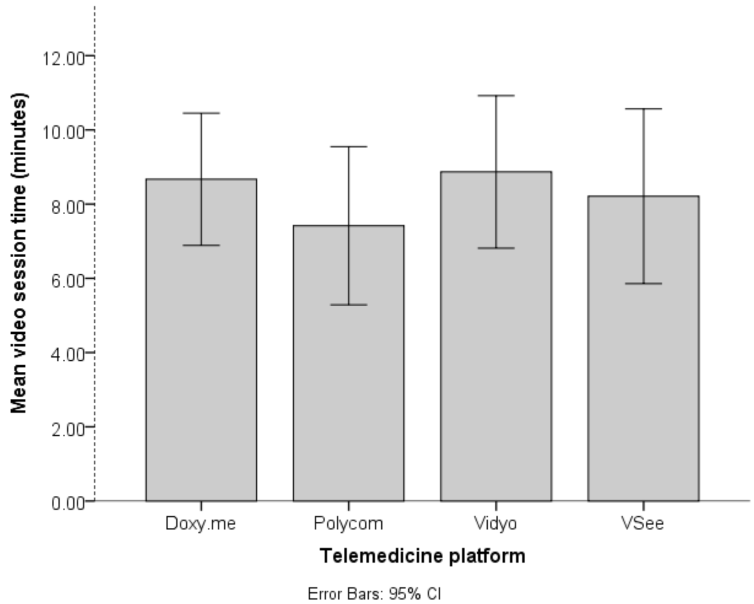

Figure 10. Mean video session time

Mean number of errors

No statistical significance was found among the telemedicine platforms for mean number of errors. $F(3,36)=1.236$, $p=0.311$.

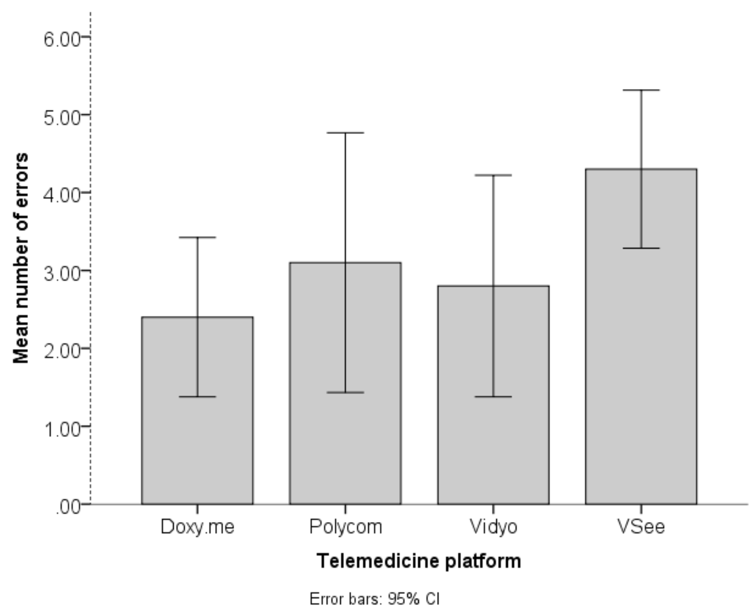

Figure 11. Mean number of errors

Mean error rate

The rate at which errors were made by the participants was found to be statistically significant for the initiation time, F(3,36)=3.331, p=0.03. The platform Polycom (M=0.432, SD=0.403) recorded the highest number of errors per minute as seen in Figure 12. The error increased from Doxy.me (M=0.049, SD=0.156) to Polycom (M=0.432, SD=0.403) and from VSee (M=0.178, SD=0.169) to Polycom (M=0.432, SD=0.403).

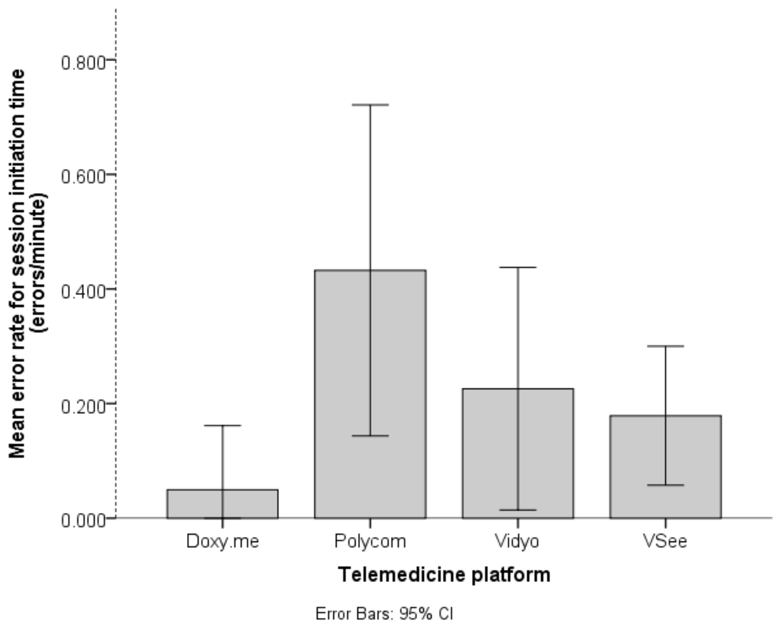

Figure 12. Mean error rate for session initiation

Statistical significance was not observed for the mean error rate for the video session, F(3,36)=0.332, p=0.802.

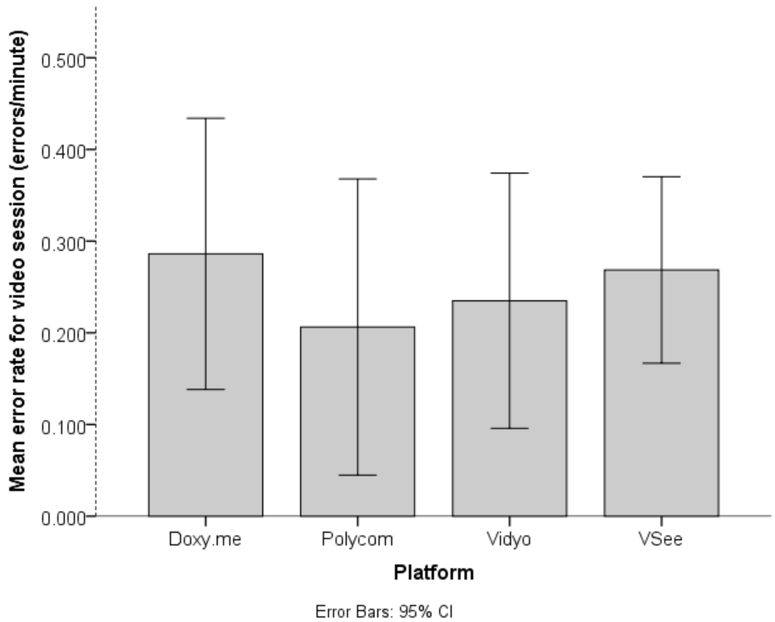

Figure 13. Mean error rate for video session

Post-test satisfaction survey

No statistical significance was found for satisfaction among the telemedicine platform, $F(3,36)=0.514$, $p=0.675$ (Figure 14). The mean and standard deviation values for the post-test satisfaction survey for the four telemedicine platforms is outlined in table 5.

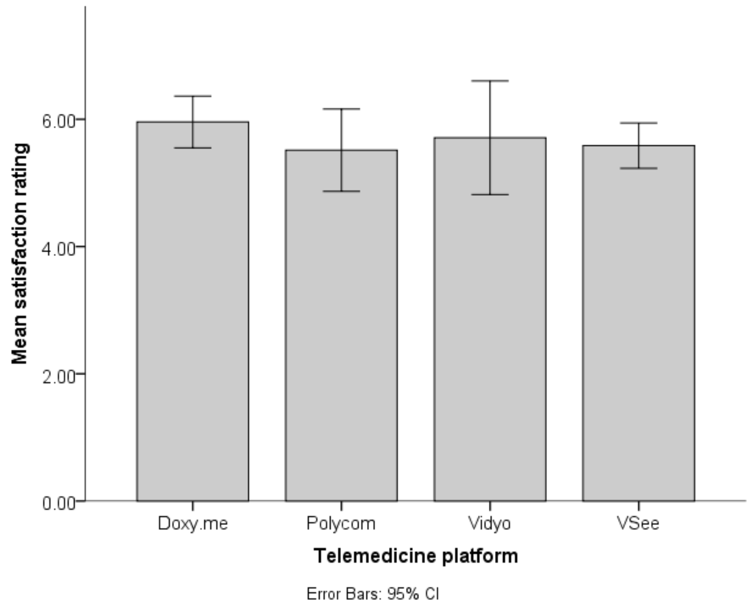

Figure 14. Post-test satisfaction ratings for telemedicine systems

NASA-TLX workload measure

The outcome of the NASA-TLX workload measure is shown in Figure 15

Workload – The univariate test showed no significance for workload for the platforms, F(3,36)=0.605, p=0.616.

Mental demand – No significance for mental demand was found for the telemedicine platforms for this metric, F(3,36)=1.192, p=0.326.

Physical demand – Physical demand showed no statistical significance, F(3,36)=0.39, p=0.761.

Temporal demand – No statistical significance was found, F(3,36)=0.468, p=0.707 for temporal demand.

Effort – No statistical significance, F(3,36)=0.589, p=0.626 was found for effort.

Frustration – No statistical significance was found for the metric frustration, F(3,36)=0.325,p=0.807.

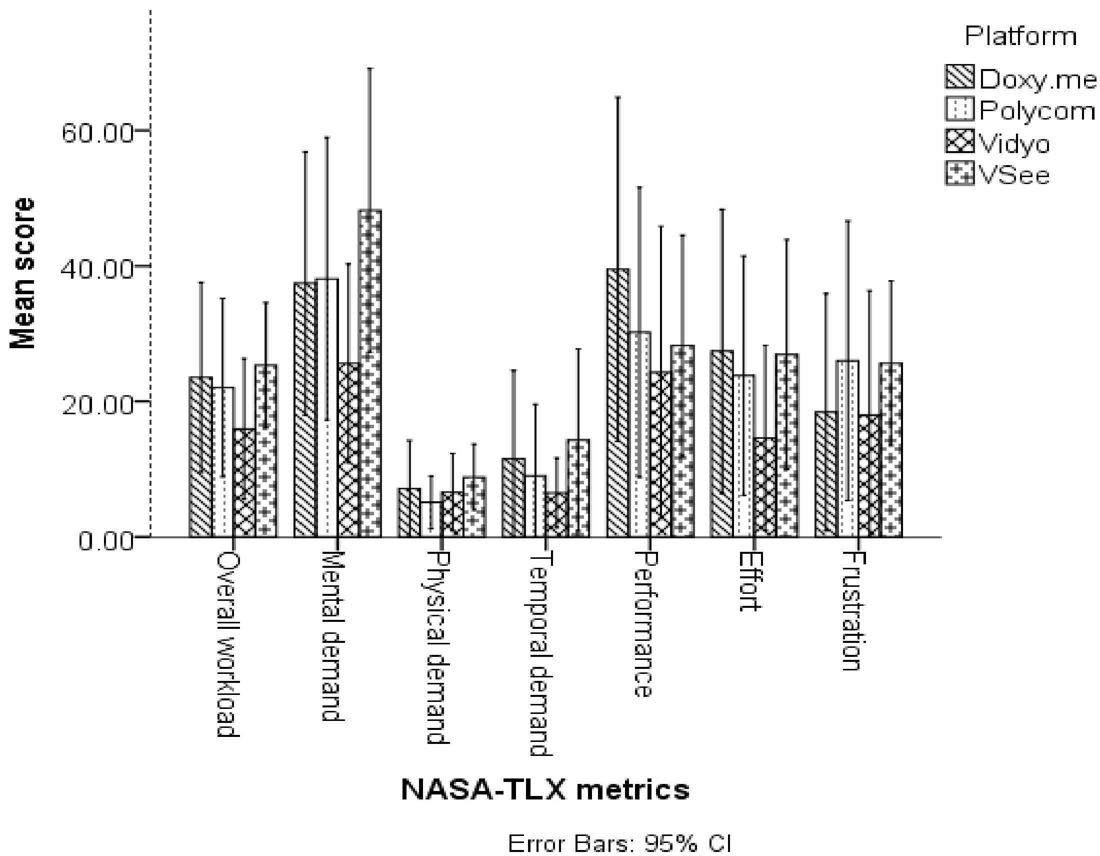

Figure 15. NASA-TLX workload measure

IBM-Computer System Usability Questionnaire (CSUQ)

The IBM-CSUQ consists of four metrics – overall usability, system usability, information quality and interface quality. Figure 16 shows the CSUQ metrics for each of telemedicine platforms investigated.

Overall usability – Overall usability showed no statistical significance, $F(3,36)=1.038, p=0.388$.

System usability –No statistical significance was found for system usability, $F(3,36)=0.875, p=0.463$.

Information quality – No statistical significance was found for this metric, F(3,36)=0.985,p=0.411.

Interface quality – No statistical significance was found for the metric interface quality, F(3,36)=2.073, p=0.121.

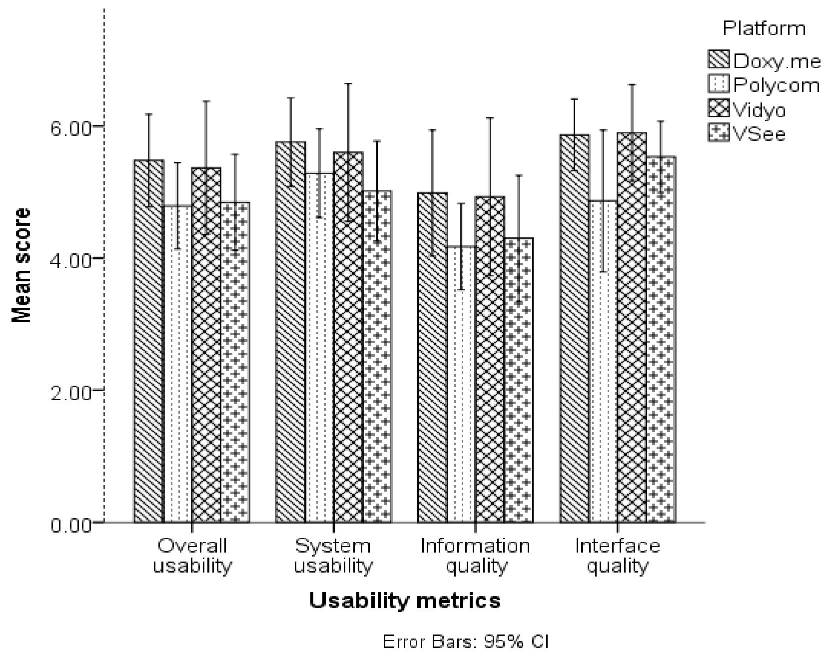

Figure 16. IBM-CSUQ measures

Cognitive task analysis

The cognitive task analysis (Militello & Hutton, 1998) conducted on the telemedicine platforms was divided into session initiation, the video session and session termination. For the initiation, Vidyo and Vsee, required the download of a plugin or desktop application. For the telemedicine video session, Doxy.me and Vsee consisted of all the capabilities required here, while Polycom did not support video toggle and chat box and Vidyo also did not support the chat box option. The platforms were uniform in terms of session termination. The tasks involved by the platforms had cognitive requirements such as selective attention, memory, literacy and basic computer and mouse operating skills. A detailed cognitive task analysis of the tasks involved in using the four telemedicine systems are shown in Table 6-9.

CHAPTER 5

DISCUSSION

The results of this investigation of the usability of telemedicine systems by the geriatric population are discussed in three sections, the issues discovered, the design suggestions for addressing them and additional outcomes.

Issues Discovered

Telemedicine session initiation

As seen in Figure 9, Doxy.me required the shortest time for initiation, whereas VSee took the longest. Data gathered from the participants during the retrospective think aloud session provided insight regarding this time difference. The participants found the one-line email invitation with the link to the webpage embedded and the entry into the virtual waiting room in Doxy.me easy to understand and follow.

On the other hand, the initiation session in VSee consisted of several steps. While the participants reported that the email invitation with a button saying "accept invitation" led to no confusion, the registration step was followed by a desktop application download. Several participants indicated the lack of feedback on clicking the download button, a situation found by the researchers to be browser dependent. In addition, several participants were unable to find and retrieve the downloaded file for completing the installation process at the end of which they were required to log into the system. At this point, these participants failed to understand that they had to login with the new credentials created during the registration step, attempting instead to login with their personal emails and passwords. A further issue was that the label "Username'' disappeared from the designated area within a few seconds of the login page opening, resulting in several participants not knowing what data to enter.

Polycom required the participants to choose the type of device and method for connecting to the video call. This process consisted of 4 options for the type of device followed by 7 options for the method. In addition, several participants did not notice the space for entering the display name on entering the care provider's virtual waiting room, probably because of the small font size. They also questioned if the display name was a prerequisite for entering the video session.

Vidyo consisted of a lengthy email invitation with 5 links, each with a different function and all hyperlinked, requiring the participants to read the email in great detail. Although this platform did not require participants to sign in, it required a plugin download, a process which confused them because the procedure shown in the instructions did not match the actual process. These issues impacted the time needed to enter the video session.

A problem commonly observed and reported by the participants for all platforms was the pop-up for sharing the microphone and camera of the hardware in use. In Doxy.me and Polycom, these pop-up boxes appeared at the top left corner of the browser, while Vidyo included the pop-up as a bar at the top of the browser page. Participants indicated that these pop-ups were not noticeable. In Doxy.me, the language used in the instructions for sharing the microphone and the camera did not correspond with that used in the pop-up, which use share instead of allow.

Telemedicine video session

During the telemedicine video session, the issues focused on the icons that appeared when the mouse was hovered over the screen, a problem seen in Doxy.me, Polycom and VSee. In addition, participants found both the icons and their labels too small in all platforms but more frequently in Vidyo and VSee. The color contrast of the icons in these last two platforms also was seen to be an area needing improvement. Enlarging the video screen in VSee required the participants to click and drag it from a corner which was inconvenient. One participant expressed concern about the symbol used to represent video toggle in VSee, suggesting that it did not represent the function appropriately, and the placement of the icons in various parts of the window in this platform was seen as inconvenient.

Furthermore, the chat box was an issue, especially for the participants unfamiliar with "chatting" who could not locate it easily. Also, after locating the chat box, they were confused regarding the area where the data were to be typed, confusing the blank area for the conversation between the end parties as an area for entering data. The instruction "type your message here" was reported to be too small and faint in Doxy.me and VSee.

Design Suggestions

Telemedicine session initiation

The email invitation should be concise with a short message and a prominent button to help the user identify it easily. Preferably, the telemedicine platform should be web-based, eliminating the need to download applications or plugins. If downloading is necessary, clear instructions matching the process should be included. To ensure easy access to the care-provider's virtual waiting room, registration should be easy, with a secure web link in the email and the patients required to enter only their names. The dialogue boxes for sharing microphones and cameras should appear in sequence, with messages being framed as yes or no questions; however, ideally the design should handle this task automatically. Further, steps such as the need to choose the devices being used to access the telemedicine system should be eliminated and the font size should facilitate easy reading. A frequent suggestion from the participants was the need for more information, specifically step-by-step instructions for navigating the platform.

Telemedicine video session

The icons and their use in the video session should remain static on the screen, be large enough so that they are clearly visible without affecting the aesthetics of the interface, provide a clear contrast from the background to promote visibility, and be placed on a distinct taskbar at the bottom center of the screen. The participant who made this last suggestion indicated it would make the platforms similar to other widely used video conferencing platforms such as Skype and IOS' Facetime. In addition, standardized and universally accepted symbols should be used to represent tasks with full screen option also provided as a button. A help menu explaining the icons and their functions could be incorporated on one side of the video session screen. Participants also suggested it be made clear that the icons on the video screen are the ones to be used during the session, not their computer/laptop controls. The chat box option should be labeled as prominently as possible to help those users unfamiliar with it, and its design should distinguish it from the messaging area by using a different color. Also, the instruction in the typing area should be darker and a little larger.

General design suggestions

An electronic instruction manual could be included in the email invitation. This manual could provide the detailed instructions for navigating the telemedicine session as suggested by the participants as well as include a basic flow chart of the tasks involved. Further details about the tasks, including an explanation of the icons, additional characteristics of the system, error correction methods and settings could be included for those interested in familiarizing themselves with the system. Another participant suggested that incorporating a simple medical form in the virtual waiting room for entering general medical data such as blood pressure and blood glucose may be helpful during the consultation with the care provider.

Additional Outcomes

Three of the 40 participants had used telemedicine in the past without knowing they had, talking via a video call, sending a photo to a doctor to consult about a bee sting and checking blood pressure levels with a nurse over the phone. The remaining participants had no prior experience with this technology. However, general discussion with the participants indicated that they were open to using it, especially for those consultations which did not require presence at the clinic. One participant with family members needing bedside assistance was very positive about the technology and its usefulness in such situations. Two participants, were reluctant to use the telemedicine system as they preferred a personal visit to the doctor, and two had to remove their hearing aids to wear the headphones used in the study. However, neither reported issues as the headphones provided good quality audio. Participants also expressed concerns about the internet connection, expressing doubt about the quality of the video session if the telemedicine system was used on a low speed broadband connection.

Other concerns raised during the discussion pertained to privacy and insurance. Participants were concerned about trusting unknown care providers with medical information. However, learning that the system would be used for follow-up visits and that the link would be sent from the same care provider’s email eased their concern. The participants also raised questions if the consultation were covered by health insurance and if it was, would they be charged an hourly rate or per tele-consultation. In addition, if the insurance charges would be based on an hourly limit, would they be charged for waiting for the care provider.

CHAPTER 6

CONCLUSIONS

The results of the study show that the geriatric population wants to stay up-to-date with new technology. Participants involved in this study showed a high level of interest in learning more about the telemedicine systems. They also indicated the need for research to make systems user-friendly to the geriatric population. This openness to help improve the system resulted in the researchers obtaining valuable input about how to improve video telemedicine systems. Through this study, an attempt at understanding this population's needs in using telemedicine systems has been made.

The suggestions provided in this article have their basis in the concepts of Human Factors. Reducing the number of steps involved in logging into the system and completing a video call with a care provider will reduce the cognitive load placed on the user. The need for a shorter, more concise email invitation will ensure that only the necessary cues are present, simplifying the log-in process. The use of a button in the email invitation will improve saliency and, thereby, promote easy detection of the tasks to be completed. The elimination of any downloads will reduce the load on the working memory as users will not have to remember these procedural steps. Icon design and placement are also important for salience and easy accessibility, and their labels will further reduce cognitive load.

Based on these design suggestions, the next step is to develop a telemedicine system integrating these considerations. This new system, tested with the same population, theoretically may be more effective in terms of time to complete the tasks and the number of errors. In addition, they may help address the degradation of the motor, vision, auditory, and other physical and cognitive abilities associated with aging. (Stronge et al. 2007; Pak and McLaughlin 2010). All of these design considerations are important to system designers as they improve the current systems or develop new ones.

Limitations

This study is not without limitations. To conduct the study with a niche population in the sparsely populated area where the university is located required us to reduce the minimum age from 65 to 60. In addition, the participant population consisted of educated people with good computer knowledge. However, even though they were not to be helped during the study, some became so anxious that they had to be prompted. Lastly, the study was conducted in a controlled environment, and the participants were not actual patients. These could also be addressed in future work in this area.

Future Work

In recent years, there has been a growth in the concept of connected health systems due to highly accessible wireless and sensor technology. (Santos, Almeida, & Perkusich, 2015/5). Smart and Connected health (SCH) aims at remote monitoring and clinical intervention using various technology. It has the potential provide preventive medical care and patient-centered clinical practice using technology such as sensors, computing tools and networking and communication hardware. This technology is expected to replace traditional clinic-based measurement by continuous monitoring and assessments using sensors, hence allowing individuals to monitor their own health.

(Wang et al., 2015) Video telemedicine systems, utilizing easily available video communication systems, may contribute to creating a connected health system. A patient may connect to a care provider from different locations with one single telemedicine platform. However, for efficient applications of such a system, a user-centered, easy-to-use platform must be designed. The suggestions provided as a result of this study may result in the development of such a system.

APPENDICES

Appendix A

Tables

Table 1. Summary of research papers

Authors	Objective	Method	Findings
Couturier et al., 1998	To investigate the feasibility of orthopedic consultation for geriatric population recuperating from fractures	15 participants were involved in the study. 5-step teleconsultation was used to determine the patient's physical situation--an interview, static clinical examination, test of walking, reading of radiograph and the conclusion. The first consultation was a teleconsultation followed by a face-to-face consultation. Clinical information from teleconsulting was noted on an evaluation form. For the feasibility study, notes made by the doctor during examination, ratings by the doctor and ratings by the patient were used.	Favorable reaction from patients (9 patients=excellent, 3 patients=good and 3 could not complete the survey because of cognitive impairment). The clinical examination was not a problem, but one patient was uncomfortable in front of the camera. 7 participants rated "acceptable", and 5 good, with a mean value of 8 and standard deviation of 1.3. Patient satisfaction was seen to be high.
Pallawala & Lun, 2001	Introduction of a new mode of delivering healthcare, a low cost alternative to traditional medical care and an examination of how people understand new technology. Focused on providing tangible and intangible benefits to patients.	The system was set up in two remote nursing homes and a geriatric hospital. Doctors conducted a detailed inspection of the patient's health before beginning the study and recorded results an EMR. When a telemedicine system required, nursing staff at elderly home created a consultation request. Using the EMR and videoconferencing, doctor communicated with patient.	Elderly patients preferred tele geriatric system as it eliminated physical problems of personal visits. Patients were confident about the teleconsultations and thought it was a valuable resource.

Table 1. Summary of research papers

Authors	Objective	Method	Findings
Hui, Woo, Hjelm, Zhang, & Tsui, 2001	To study the feasibility of providing telemedicine to patients in a nursing home and its impact on productivity and savings.	200 participants were involved in the study. Dermatological and podiatric services were provided via real time video calls. Follow up consultations were also provided this way. If patient felt the need for face-to-face consultation, it would take place the same day or the next morning.	Depending on the specialty, 82-95% of the clients were satisfied with telemedicine and favored it. Telemedicine was cheaper than conventional method. Patients asked for face-to-face consultation only in cases where physical examination was necessary or there were serious communication issues. Inability to hear or see the specialist in some situations and lack of confidence in teleconsultation.
Kobb, Hoffman, Lodge, & Kline, 2003	Provide care to chronically ill Veterans (Rural Home Care Project) with the aim of reducing hospitalization, emergency room visits and prescription medicine cost.	281 participants were included in the intervention group and the control group consisted of 1120 participants. Veteran in normal care and in RHCP were compared. Veterans within the RHCP were compared before and after being a part of the program. At the beginning of the program, veterans completed a tool for validating function and perceived health. All other interviews were done by telephone. Customer satisfaction reports were collected every 6 months.	Patients satisfaction survey conducted over 6 months indicated high rates of satisfaction

Table 1. Summary of research papers

Authors	Objective	Method	Findings
Corcoran, Hui, & Woo, 2003	To investigate the applicability and acceptance of telemedicine in podiatry.	49 participants took part in the study. A podiatrist carried out a foot examination via videoconference and then a treatment plan was determined.	87% chose telemedicine over being transported to a hospital for podiatric care. Some said teleconsultation was more convenient and less expensive.
Wiborg, Widder, & Telemedicine in Stroke in Swabia Project, 2003	To understand the feasibility, acceptance and economic effects of using telemedicine.	153 participants took part in the study. Local physician at participating hospital investigated the use of teleconferencing in a stroke care center. The video call is placed and patient history is provided along with results. CT scan is examined and a decision is made about further steps.	Patients were satisfied with the tele-examination and commented that it was easy to speak to and cooperate with the neurologist. Analysis of patient and CT scans in case of acute stroke care is possible through telemedicine. Transport time due to telemedicine followed by a physical examination (where necessary) led to need of extra time.

Table 1. Summary of research papers

Authors	Objective	Method	Findings
Poon, Hui, Dai, Kwok, & Woo, 2005	To compare the feasibility, acceptability and the clinical outcome of a cognitive intervention (CI) program started for the elderly with mild cognitive impairment and mild dementia using telemedicine and face-to-face methods.	The intervention group and the control group each consisted of 11 participants. Candidates were screened using Cantonese version of Mini Mental State Examination. Qualified patients were categorized randomly into videoconferencing group and face-to-face interaction group. Using cameras set-up, the telemedicine session was carried out	Majority of the videoconferencing group preferred the method. Both groups showed improvements in areas of attention and memory, calculation and language on dementia scale. The two groups did not differ significantly in neuropsychological outcomes.
Schofield et al., 2005	To study the effects of enrolling in a home telecare program for heart failure but without randomization or controls	73 participants were included in the study. At baseline, patient history of illness and basic reading of weight, blood pressure were collected. Telephonic interviews were carried out by Veteran Health Administration (VHA) staff for 6 months. Patients were also asked health- related question using the in-home messaging device provided.	Patient satisfaction with care coordination and the use of technology for overall program was 94% Before the study, 75% of the patients had recent hospitalizations but during the study only 11% were hospitalized. The mean Bed Days of Care (BDOC) was reduced.

Table 1. Summary of research papers

Authors	Objective	Method	Findings
Parker Oliver, Demiris, & Porock, 2005	To investigate the acceptance and usability of videophone technology for telemedicine.	12 participants were involved in the study. Demonstration booth was set up requiring the participants to call a number connect to the researcher. They were then given an overview of the study and told to call another number to connect to a doctor through a video call. They were then questioned about their impression of and experience using the system.	71% of participants affirmed that the technology was easy-to-use. Participants found it comfortable to use the videophone and would adopt it if it was provided in their residence. People with hearing impairment found it difficult to use the videophone. Others who read lips could not do so due to lag in the video. An issue was raised regarding inability to read numbers on the phone button due to the color.
Lamothe, Fortin, Labbé, Gagnon, & Messikh, 2006	To study the effects of Home telehealth on the elderly with chronic heart conditions. Results supported previous research outcomes on its positive effect on patients and providers.	82 participants were studied. Patients had a local monitor with apparatus. On a regular basis, patients had to take and send medical readings. A nurse at the central monitor responded to alerts either via telephone calls or a nurse was sent to the patient's home.	Patients had difficulty using the monitor. Patients and caregivers thought it was a better means for accessing the services. Reduced visits to the ED. Patients were satisfied with use of home telehealth. Other advantages mentioned - not necessary to visit the doctor for BP, no waiting time for nurse to take BP reading before meeting doctor

Table 1. Summary of research papers

Authors	Objective	Method	Findings
Jasemian, 2008	To understand and evaluate the compliance, trust and comfort in using real-time telemedicine systems at their home.	Study consisted of 24 non-risky heart patients. Participants had to wear a vest which measured their ECG during their daily activities. Vitals were transmitted from the vest to a mobile phone and in turn to the researcher. In case of uncommon ECG reading, the participants were contacted via telephone.	80% of the participants thought the systems was user friendly and system had good usability. 76% rated reliability aspect as 'good'. 84% felt their privacy expectations were met. 72% trusted the system and 80% also indicated that they were comfortable using the system.
Makai et al., 2014	To study the success of an Online Health Community (OHC) program for older people to help in obtaining multidisciplinary communication	The intervention group consisted of 291 participants with 392 were included in the control group. The patients in the intervention group were observed using Zorg en Welzijns Informatie Portaal (ZWIP). Nurses performed measures and patient feedback was initially obtained and then subsequently at regular intervals in face-to-face meetings.	76/290 (26.2%) of the intervention group participants used ZWIP actively. The small number may be an indication that introducing new technology to the elderly is difficult. Despite theory-driven intervention design and implementation techniques, usage and effectiveness were low.

Table 1. Summary of research papers

Authors	Objective	Method	Findings
Czaja, Lee, Arana, Nair, & Sharit, 2014	To investigate the feasibility and to determine the problems associated with telemedicine.	The study included 34 participants. Participants had to upload BP and weight every day. Doctors sent reminders to patients daily. In case of abnormal BP reading, the nurse at the Home Care Service Center was informed via email and a message was sent to the patient's message system to relax and retake the readings. If the erratic values continued, the nurse contacted the patient with further instructions.	92% of participants found it easy-to-use. 92% also felt they could follow their medical schedule better 67% confirmed that it made them feel better It was observed that experience with technology helped people use the system. Some patients had trouble using the equipment.
Vermeersch, Sampsel, & Kleman, 2015	To explore the acceptability and usability of a Remote Presence Robot (RPR) using providers and older adults.	13 participants were involved in the study. Participant signed into study and was provided a survey. An Advanced Practice Registered Nurse (APRN) greeted participant through the RPR. Patient measured weight, height and reads Snellen chart for eyesight test. For the physical examination, the APRN observed the participant's exposed skin, while walking, sitting or standing and directed patient to place attached stethoscope on heart.	Participants reported higher positive responses. Residents rated more than 4/5 for both effectiveness and usability. Positive comments about effectiveness concerning the APRN operating the RPR while making suitable comments. However, a few comments were made about the technology such as having better temperature measuring devices and reduced glare of lights during examination.

Table 1. Summary of research papers

Authors	Objective	Method	Findings
Grosch, Weiner, Hynan, Shore, & Cullum, 2015	To study the hypothesis that video teleconference (VTC) based screening for neurocognitive problems is feasible and gives the same results as face-to-face consultation.	8 participants were involved in the study. Global cognition, attention and visuospatial function were tested using three neurocognitive tests. Once completed, the patients held their test papers in front of the webcam for the physician to assess.	Interviews with participants showed that they were satisfied with VTC testing procedure. Mean measures from the tests indicated similar values for both methods.
Shah et al., 2016	To study the effect of Health-e-access, a high intensity telemedicine program for older people, on the use of Emergency Departments.	The intervention group contained 495 participants with 1058 included in the control group. On falling ill, the patient or a caregiver called the medical service. The care provider provided a solution through immediate visit or telemedicine. In case of a telemedicine visit, an assistant collected health details from patient's home which were uploaded onto EMR. The doctor, contacted by the assistant, then provided necessary feedback.	86.7% of patients indicated they would choose telemedicine in the future, Indicating a high rate of acceptability. Individuals in the program saw a decrease in the ED visits with Health-e-access.

Table 2. Criteria for patient selection

Author	Age criterion only	Cognitive impairment and Dementia	Gero Psychiatry	Chronic systolic heart failure	Common healthcare issues /health cost	Multidisciplinary care	Cardiac insufficiency, hypertension, diabetes	Blood Pressure	Foot problems	Stroke care	Geriatric orthopedics	Affiliation to a nursing home	Cardiac Arrhythmia
Couturier et al., 1998											•		
Pallawala & Lun, 2001	•												
Hui, Woo, Hjelm, Zhang, & Tsui, 2001	•												
Kobb, Hoffman, Lodge, & Kline, 2003					•								
Corcoran, Hui, & Woo, 2003									•				

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Wiborg, Widder, & Telemedicine in Stroke in Swabia Project, 2003										•			
Poon, Hui, Dai, Kwok, & Woo, 2005		•											
Schofield et al., 2005				•									
Parker Oliver, Demiris, & Porock, 2005												•	
Lamothe, Fortin, Labbé, Gagnon, & Messikh, 2006							•						

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Jasemian, 2008													•
Makai et al., 2014						•							
Czaja, Lee, Arana, Nair, & Sharit, 2014								•					
Vermeersch, Sampsel, & Kleman, 2015	•												
Grosch, Weiner, Hynan, Shore, & Cullum, 2015			•										
Shah et al., 2016	•												

Table 3. Communication devices used

Author	Computer	Telephone	Videophone	Messaging devices	Television	Videoconferencing equipment	Robot
Couturier et al., 1998	●						
Pallawala & Lun, 2001	●						
Hui, Woo, Hjelm, Zhang, & Tsui, 2001					●		
Kobb, Hoffman, Lodge, & Kline, 2003	●	●		●			
Corcoran, Hui, & Woo, 2003	●						
Wiborg et al., 2003					●		
Poon, Hui, Dai, Kwok, & Woo, 2005	●						
Schofield et al., 2005		●		●			

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Jasemian, 2008		●					
Makai et al., 2014	●						
Czaja, Lee, Arana, Nair, & Sharit, 2014		●		●			
Vermeersch, Sampsel, & Kleman, 2015							●
Grosch, Weiner, Hynan, Shore, & Cullum, 2015						●	
Shah et al., 2016	●	●					

Table 4. Data transmission method

Author	Broadband	Wireless	Telephone Line	ISDN	ADSL	Coaxial Cable	GSM/GPRS	Unknown
Couturier et al., 1998						●		
Pallawala & Lun, 2001					●			
Hui, Woo, Hjelm, Zhang, & Tsui, 2001				●				
Kobb, Hoffman, Lodge, & Kline, 2003			●					
Corcoran, Hui, & Woo, 2003				●				
Wiborg, Widder, & Telemedicine in Stroke in Swabia Project, 2003				●				
Poon, Hui, Dai, Kwok, & Woo, 2005	●							
Schofield et al., 2005								●

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Lamothe, Fortin, Labbé, Gagnon, & Messikh, 2006		•						
Jasemian, 2008							•	
Makai et al., 2014								•
Czaja, Lee, Arana, Nair, & Sharit, 2014			•					
Vermeersch, Sampsel, & Kleman, 2015		•						
Grosch, Weiner, Hynan, Shore, & Cullum, 2015	•							
Shah et al., 2016								•

Table 5. Post-test satisfaction survey ratings

Question	Doxy.me		Polycom		Vidyo		VSee	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
I can easily talk to my health care provider through this telemedicine system.	6.5	0.527	5.2	1.873	5.5	1.957	6.1	0.737
I can hear my health-care provider clearly through this telemedicine system.	6.6	0.516	6.2	0.788	6.8	0.421	6	1.825
I can see my health-care provider as if we met in person via this telemedicine system.	6.5	0.527	5.2	2.097	6.1	1.852	6.5	0.527
I do not need assistance while using this telemedicine system.	5.4	1.429	4.4	1.577	5	1.763	3.9	1.523
I feel comfortable communicating with my health-care provider with this telemedicine system.	6.2	0.632	5.3	1.702	5.8	1.873	5.8	1.135

I think the health-care provided via this telemedicine system is consistent.	6.1	0.875	5.6	1.264	5.2	1.873	5.9	0.737
I obtain better access to health-care services by use of this telemedicine system.	5.3	1.059	4.5	1.509	4.3	2.002	5.7	0.674
This telemedicine system saves me time traveling to hospital or a specialist clinic.	6.3	0.948	6.4	0.699	6.5	0.707	6.4	0.516
I do receive adequate attention.	6	0.816	5.7	1.337	6.2	1.032	6.2	0.632
I find this telemedicine system an acceptable way to receive health-care services	6	0.816	5.6	1.349	5.7	2.002	5.8	0.632
Overall, I am satisfied with the quality of service being provided via this telemedicine system.	6	0.666	5.8	1.398	5.7	1.946	6	0.471

Using this telemedicine system enables me to complete my consultation more quickly.	6.1	0.994	6.1	0.875	5.8	1.873	6	0.816
This telemedicine system can improve my access to health care services.	5.9	1.100	6.2	0.788	5.8	1.932	6	0.471
This telemedicine system can help me improve my health.	5.5	1.178	5.3	1.059	5.5	2.013	5.4	0.699
Using this telemedicine system can make my health care and management easier.	5.8	0.918	6	0.942	5.6	1.897	5.6	0.843
I would find this telemedicine system useful for my health care and management.	5.8	1.135	5.9	0.875	5.6	1.837	5.9	0.737
Learning to use this telemedicine system is easy for me.	5.9	1.197	4.9	1.595	5.5	1.779	4.8	1.549

I find it easy to get this telemedicine system to do what I need to do in my health care and management.	5.4	0.966	4.8	1.316	5.4	1.897	4.8	1.549
My interaction with this telemedicine system is clear and understandable.	5.7	1.337	5.6	1.173	5.8	1.316	4.6	1.505
I find this telemedicine system to be flexible to interact with.	6	0.666	5.5	1.080	6.1	0.875	4.9	1.595
It is easy for me to become skillful at using this telemedicine system.	6.1	0.875	5.6	1.577	6	0.816	5	1.699

Table 6. Cognitive task analysis for Doxy.me

Task #	Subtasks/steps involved	Sensory/Perceptual demand	Cognitive demands	Response demands
1.0	Session initiation			
1.1	Access email invitation	Vision and perceptual recognition: Read and understand the email invitation. Locate the appropriate link on the invitation email	Text literacy/comprehension and long term memory: Understand instructions in the email Understand and remember basic mouse and window operations	
1.2	Access web link for telemedicine session	Vision and perceptual recognition: Read and understand the email invitation Locate the appropriate link on the invitation email	Text literacy/comprehension and long term memory: Identify the web link Understand and remember basic mouse and window operations	Fine motor skills/dexterity: Position cursor on link Select link by clicking the mouse
1.3	Check into the virtual waiting room	Vision and perceptual recognition: Recognize area to enter name Enter name Click on check-in button	Text literacy/comprehension and long term memory: Understand basic mouse and keyboard operations	Fine motor skills/dexterity: Position cursor in typing area Type using keyboard Position cursor on check-in button Select by clicking the mouse

1.4	Allow for microphone and camera access	Vision and perceptual recognition: Recognize pop-up to carry out task Read instructions given and click allow	Selective attention, text literacy/comprehension and long term memory: Recognize device sharing pop-up Understand instructions provided Ignore irrelevant information on the page Understand basic mouse operations	Fine motor skills/dexterity: Position cursor on allow button Select by clicking the mouse
2.0	Video session			
2.1	Access microphone mute	Vision and perceptual recognition: Locate mute microphone icon Read label for icon	Selective attention, text literacy/comprehension and long-term memory: Recognize mute microphone icon Read and understand label for icon Ignore irrelevant information on the page Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on mute microphone icon Select by clicking the mouse
2.2	Access video toggle	Vision and perceptual recognition: Locate video toggle icon Read label for icon	Selective attention, text literacy/comprehension and long-term memory: Recognize video toggle icon Read and understand label for the icon	Fine motor skills/dexterity: Position cursor on video toggle icon Select by clicking the mouse

			Ignore irrelevant information on the page Understand basic mouse operation	
2.3	Access full screen	Vision and perceptual recognition: Locate full screen icon Read label for icon	Selective attention, text literacy/comprehension and long-term memory: Recognize fullscreen icon Read and understand label for the icon Ignore irrelevant information on the page Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on full screen icon Select by clicking the mouse
2.4	Access chat box	Vision and perceptual recognition: Locate chat box icon	Selective attention, text literacy/comprehension, basic numeracy and long-term memory: Recognize chat box icon Read and understand label for the icon Understand blood pressure values provided Ignore irrelevant information on the page Understand basic mouse and keyboard operations	Fine motor skills/dexterity: Position cursor on chat icon Select by clicking the mouse Type blood pressure value using keyboard
3.0	Video session termination			

3.1	Access end call	Vision and perceptual recognition: Locate end call icon	Selective attention, text literacy/comprehension and long-term memory: Recognize end call icon Read and understand label for the icon Ignore irrelevant information on the page Understand basic mouse operations	Fine motor skills/dexterity: Position cursor on end call icon Select by clicking the mouse

Table 7. Cognitive task analysis for Polycom

Task #	Subtasks/steps involved	Sensory/Perceptual demand	Cognitive demands	Response demands
1.0Session initiation				
1.1	Access email invitation	Vision and perceptual recognition: Read the email invitation Locate the appropriate link on the invitation email	Text literacy/comprehension and long term memory: Identify the web link Understand and remember basic mouse and window operations	Fine motor skills/dexterity: Position cursor on link Select link by clicking the mouse
1.2	Access device option in welcome page	Vision and perceptual recognition: Read different device options for using telemedicine system	Text literacy/comprehension and long term memory: Read and recognize the device being used Understand basic mouse operation	Fine motor skills/dexterity: Scrolling, Position cursor on computer option

				Select device by clicking the mouse
1.3	Access using your browser option	Vision and perceptual recognition: Read different ways of using the platform on a computer	Text literacy/comprehension and long term memory: Read and recognize the method of using the platform Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on Using your browser option Select by clicking mouse
1.4	Click get started	Vision and perceptual recognition: Locate get started button	Text literacy/comprehension and long term memory: Read and understand the get started label Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on get started option Select by clicking mouse
1.5	Access microphone and camera sharing pop-up	Vision and perceptual recognition: Locate share device button	Text literacy/comprehension working memory and long term memory: Locate and comprehend pop-up to share microphone and camera Understand instructions to share devices Ignore irrelevant information on the page Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on share devices option Select by clicking mouse
1.6	Click test to test speakers	Vision and perceptual recognition:	Text literacy/comprehensio	Fine motor skills/dexterity:

		Locate test button	n and long term memory: Read and understand test labels for the task Ignore irrelevant information on the page Understand basic mouse operation	Position cursor on test option Select by clicking mouse
1.7	Enter display name	Vision and perceptual recognition: Locate area to enter display name	Text literacy/comprehension and long term memory: Read and understand labels in area to enter name Ignore irrelevant information on the page Understand basic mouse and keyboard operation	Fine motor skills/dexterity: Position cursor on enter display name area Select by clicking the mouse Type name using keyboard
1.8	Click on join now button	Vision and perceptual recognition: Locate join now button	Text literacy/comprehension and long term memory: Read and understand label to join video call Ignore irrelevant information on the page Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on join now button Select by clicking the mouse
2.0	Video session			
2.1	Access microphone mute	Vision and perceptual recognition:	Selective attention, text literacy/comprehensio	Fine motor skills/dexterity:

		Locate mute microphone icon Read label for icon	n and long-term memory: Recognize mute microphone icon Read and understand label for icon Ignore irrelevant information on the page Understand basic mouse operation	Position cursor on 'mute microphone' icon Select by clicking the mouse
2.2	Access full screen	Vision and perceptual recognition: Locate full screen icon Read label for icon	Selective attention, text literacy/comprehension and long-term memory: Recognize full screen icon Read and understand label for the icon Ignore irrelevant information on the page Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on full screen icon Select by clicking the mouse
3.0	Video session termination			
3.1	Access end call	Vision and perceptual recognition: Locate end call icon	Selective attention, text literacy/comprehension and long-term memory: Recognize end call icon Read and understand label for the icon Ignore irrelevant information on the page Understand basic mouse operations	Fine motor skills/dexterity: Position cursor on end call icon Select by clicking the mouse

Table 8. Cognitive task analysis for Vidyo

Task #	Subtasks/steps involved	Sensory/Perceptual demand	Cognitive demands	Response demands
1.0	Session Initiation			
1.1	Access email invitation	Vision and perceptual recognition: Read the email invitation Locate the appropriate link on the invitation email	Text literacy/comprehension and long term memory: Identify the web link Understand and remember basic mouse and window operations	Fine motor skills/dexterity: Position cursor on link Select link by clicking the mouse
1.2	Download plugin	Vision and perceptual recognition: Read the downloading instructions Locate and comprehend accept and download button label	Text literacy/comprehension working memory and long term memory: Read and understand instructions for downloading Remember subsequent steps in download procedure Remember to locate and run downloaded file Discriminate among the different steps of the download procedure Ignore irrelevant information on the page Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on the on the right option Select option by clicking the mouse

1.3	Join call	Vision and perceptual recognition: Read label to enter name Locate join call option	Text literacy/comprehension, working memory and long term memory: Read and comprehend instructions to enter name Remember and comprehend label indicating method to join call Understand basic mouse and keyboard operation	Fine motor skills/dexterity: Position cursor on space to enter name Select by clicking the mouse Enter name using keyboard Place cursor on join call button Select by clicking mouse
2.0	Video session			
2.1	Access microphone mute	Vision and perceptual recognition: Locate mute microphone icon Read label for icon	Selective attention, text literacy/comprehension and long-term memory: Recognize mute microphone icon Read and understand label for icon Ignore irrelevant information on the page Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on mute microphone icon Select by clicking the mouse
2.2	Access video toggle	Vision and perceptual recognition: Locate video toggle icon Read label for icon	Selective attention, text literacy/comprehension and long-term memory: Recognize video toggle icon Read and understand label for the icon	Fine motor skills/dexterity: Position cursor on video toggle icon Select by clicking the mouse

			Ignore irrelevant information on the page Understand basic mouse operation	
2.3	Access full screen	Vision and perceptual recognition: Locate full screen icon Read label for icon	Selective attention, text literacy/comprehension and long-term memory: Recognize full screen icon Read and understand label for the icon Ignore irrelevant information on the page Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on full screen icon Select by clicking the mouse
3.0	Video session termination			
3.1	Access end call	Vision and perceptual recognition: Locate end call icon	Selective attention, text literacy/comprehension and long-term memory: Recognize end call icon Read and understand label for the icon Ignore irrelevant information on the page Understand basic mouse operations	Fine motor skills/dexterity: Position cursor on end call icon Select by clicking the mouse

Table 9. Cognitive task analysis for VSee

Task #	Subtasks/steps involved	Sensory/Perceptual demand	Cognitive demands	Response demands
1.0	Session initiation			
1.1	Access email invitation	Vision and perceptual recognition: Read the email invitation Locate the accept invite button	Text literacy/comprehension and long term memory: Read and understand instructions in the email Identify invitation accept button Understand and remember basic mouse and window operations	Fine motor skills/dexterity: Position cursor on link Select link by clicking the mouse
1.2	Register for the telemedicine platform	Vision and perceptual recognition: Read data required to register Locate appropriate areas to enter details Locate the register button	Text literacy/comprehension working memory and long term memory: Read and understand data required for registration Identify areas to enter details first name, last name and password Read and understand label to register Understand and remember basic mouse and keyboard operations	Fine motor skills/dexterity: Position cursor on area to enter detail Select by clicking the mouse Enter details using keyboard Position cursor on register button Select by clicking the mouse
1.3	Download desktop application	Vision and perceptual recognition: Read the downloading instructions	Text literacy/comprehension working memory and long term memory: Read and understand instructions for downloading	Fine motor skills/dexterity: Position cursor on the on the right option

		Locate and comprehend accept and download button label	Remember subsequent steps in download procedure Remember to locate and run downloaded file Discriminate among the different steps of the download procedure Ignore irrelevant information on the page Understand basic mouse operation	Select option by clicking the mouse
1.4	Log into the platform	Vision and perceptual recognition: Read instructions to log in Locate area to enter username and password Locate login button	Text literacy/comprehension working memory and long term memory: Read and comprehend instructions to log in Locate area to type username and password Locate and understand labels provided Understand basic mouse and keyboard operations	Fine motor skills/dexterity: Position cursor in the appropriate area Select by clicking the mouse Type required information using keyboard Position cursor on the login button Select by clicking on the mouse
1.4	Access camera sharing option	Vision and perceptual recognition: Read instructions provided Locate yes button	Selective attention, text literacy/comprehension, working memory and long term memory: Locate and comprehend instructions provided Locate and understand labels provided	Fine motor skills/dexterity: Position cursor on yes option Select by clicking mouse

			Recognize self-view in self-view window Ignore irrelevant information Understand basic mouse operation	
1.5	Access sound test option	Vision, auditory and perceptual recognition: Read instructions provided Locate yes button	Selective attention, text literacy/comprehension, working memory and long term memory: Locate and comprehend instructions provided Locate and understand labels provided Recognize test sound Ignore irrelevant information Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on yes option Select by clicking mouse
1.6	Access microphone test option	Speech, Vision and perceptual recognition: Read instructions provided Speak into the microphone Locate yes button Locate done button	Selective attention, text literacy/comprehension, working memory and long term memory: Locate and comprehend instructions provided Locate and understand labels provided Recognize red line when speech input is detected Ignore irrelevant information Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on yes option Select by clicking mouse Position cursor on ‘done’ option Select by clicking mouse
2.0	Video session			
2.1	Access video call	Vision and perceptual recognition:	Selective attention, text literacy/comprehension, and long term memory:	Fine motor skills/dexterity:

		Locate accept button for incoming video call	Read and understand labels provided Understand basic mouse operation	Position cursor on the accept button Select by clicking the mouse
2.2	Access microphone mute	Vision and perceptual recognition: Locate mute microphone icon Read label for icon	Selective attention, text literacy/comprehension and long-term memory: Recognize mute microphone icon Read and understand label for icon Ignore irrelevant information on the page Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on mute microphone icon Select by clicking the mouse
2.3	Access video toggle	Vision and perceptual recognition: Locate video toggle icon Read label for icon	Selective attention, text literacy/comprehension and long-term memory: Recognize video toggle icon Read and understand label for the icon Ignore irrelevant information on the page Understand basic mouse operation	Fine motor skills/dexterity: Position cursor on video toggle icon Select by clicking the mouse
2.4	Access full screen	Vision and perceptual recognition: Locate full screen icon Read label for icon	Selective attention, text literacy/comprehension and long-term memory: Recognize fullscreen icon Read and understand label for the icon Ignore irrelevant information on the page	Fine motor skills/dexterity: Position cursor on full screen icon Select by clicking the mouse

			Understand basic mouse operation	
2.5	Access chat box	Vision and perceptual recognition: Locate chat box icon	Selective attention, text literacy/comprehension, basic numeracy and long-term memory: Recognize chat box icon Read and understand label for the icon Understand blood pressure values provided Ignore irrelevant information on the page Understand basic mouse and keyboard operations	Fine motor skills/dexterity: Position cursor on chat icon Select by clicking the mouse Type blood pressure value by using keyboard
3.0	Video session termination			
3.1	Access end call	Vision and perceptual recognition: Locate end call icon	Selective attention, text literacy/comprehension and long-term memory: Recognize end call icon Read and understand label for the icon Understand basic mouse operations	Fine motor skills/dexterity: Position cursor on end call icon Select by clicking the mouse

Appendix B

Consent Form

Consent Form for Participation in a Research Study

Clemson University

An Investigation on the Usability of Home-based Video Telemedicine Systems

Description of the research and your participation

You are invited to participate in a research study conducted by Shraddhaa Narasimha, Dr. Kapil Chalil Madathil and Sruthy Orozhiyathumana Agnisarman. The purpose of this study is to compare the usability of different telemedicine software platforms. Telemedicine is the use of electronic information and communications technologies to provide and support healthcare when distance separates participants. The study will compare the usability of the following four telemedicine platforms: Vidyo, Polycom, Doxy.me and Vsee. Usability testing is a systematic way of observing actual users trying out a product and collecting information about the specific ways in which the product is easy or difficult for them to use. In this study, the doctor (a student will act as doctor) will send you an invitation to your email id and by clicking the link you will be directed to a telemedicine session.

The researcher will give you a brief description of the study. You will be asked to fill out a brief questionnaire about yourself and your knowledge of computers and the internet. Then you will be asked to complete a telemedicine session, followed by a retrospective think-aloud session. You will then be asked to fill out a subjective questionnaire about that software to help us to evaluate your satisfaction with it. The amount of time required for your participation will be approximately one hour.

Please understand that we are not testing your personal capabilities. We are testing the usability of the telemedicine platforms.

Risks and discomforts

There are no known risks associated with this study. The experiment does not require anything more than watching a typical computer monitor and talking to a doctor through microphone. You will be allowed to take breaks to rest, and you may quit the research at any time without penalty.

Potential benefits

There are no known benefits to you that would result from your participation in this research. This research may help us to understand how to develop more user-friendly telemedicine software.

Protection of confidentiality

We will do everything we can do to protect your privacy. The data captured will be stored on a password-protected computer in the Fluor Daniel 326. The surveys will be kept in a locked cabinet. The documents will be accessible only to the principal investigator and co-investigators. Your identity will not be revealed in any publication that might result from this study.

In rare cases, a research study will be evaluated by an oversight agency, such as the Clemson University Institutional Review Board or the federal Office for Human Research Protections that would require that we share the information we collect from you. If this happens, the information would only be used to determine if we conducted this study properly and adequately protected your rights as a participant.

Voluntary participation

Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

If you choose to stop taking part in this study, the information you have already provided will be used in a confidential manner.

Participant incentives

You will be awarded a $25 gift card.

Contact information

If you have any questions or concerns about this study or if any problems arise, please contact Dr. Kapil Chalil Madathil at Clemson University at 864-656-0857. If you have any questions or concerns about your rights as a research participant, please contact the Clemson University Institutional Review Board at 864-656-0636.

Consent

I have read this form and have been allowed to ask any questions I might have. I agree to take part in this study.

Appendix C

Surveys

Demographic Survey

1. Do you agree to the consent form?

- Yes
- No

2. Gender
- Male
- Female

3. Year of Birth -

4. What is the highest level of education you have completed?
- Less than High School
- High School / GED
- Some College
- 2-year College Degree
- 4-year College Degree
- Master's Degree
- Doctoral Degree
- Professional Degree (JD, MD)

5. What is your race?
- White/Caucasian
- African American
- Hispanic
- Asian
- Native American
- Pacific Islander
- Other

6. Present employment status:
● Full Time
● Part Time
● Retired
● Unemployed

7. Which place best describes where you grew up?
● Urban
● Suburban
● Rural

8. In general, would you say your health is:
● Excellent
● Very good
● Good
● Fair
● Poor

9. How many times in the past month...

	Never	A little of the time	Some of the time	A good bit of the time	Most of the time	All of the time
Were you discouraged by your health problems?	o	o	o	o	o	o
Were you fearful about your future health?	o	o	o	o	o	o

10. Do you have a machine to measure your blood sugar (glucose) level?
- Yes
- No

11. On days that you test your blood sugar, how many times do you test on average?

12. How confidently can you judge when the changes in your illness mean you should visit the doctor?

13. How long have you been using computers?
- Less than a year
- 1 - 3 years
- 3 - 5 years
- More than 5 years

14. Which operating system do you use on a regular basis?
- Windows
- Apple Mac
- Linux

15. How comfortable do you feel using the Internet?
- Very uncomfortable
- Somewhat uncomfortable
- Neither comfortable nor uncomfortable
- Somewhat comfortable
- Very comfortable

16. Which browser do you use on a regular basis?
- Google Chrome
- Mozilla Firefox
- Internet Explorer
- Opera
- Safari

17. Which of the following technology products do you currently own or use regularly?

	Yes, with web access	Yes, without web access	No
Cell Phone	o	o	o
PDA (e.g., Palm Pilot, Pocket PC)	o	o	o
Computer at work	o	o	o
Computer at home	o	o	o
Public access computer (e.g. cafe, library, school)	o	o	o

18. If you have access to the web, how do you access?
● Through dial up access
● Through broadband access

19. How often do you go online?
● Never
● Less than Once a Month
● Once a Month
● 2-3 Times a Month
● Once a Week
● 2-3 Times a Week
● Daily

21. How successful are you at finding information on the Internet?
● I don't use the internet
● Very unsuccessful
● Unsuccessful
● Neither successful, nor unsuccessful
● Successful
● Very successful

22. How often do you use an online social networking site like MySpace, Facebook or Twitter?
● Never

- Less than once a month
- Once a month
- 2-3 times a month
- Once a week
- 2-3 times a week
- Daily

Post-Test Questionnaire

1. Participant Number (To be filled by researcher)

2. I can easily talk to my health care provider through this telemedicine system.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

3. I can hear my health-care provider clearly through this telemedicine system.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

4. I can see my health-care provider as if we met in person via this telemedicine system.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

5. I do not need assistance while using this telemedicine system.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

6. I feel comfortable communicating with my health-care provider with this telemedicine system.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

7. I think the health-care provided via this telemedicine system is consistent.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

8. I obtain better access to health-care services by use of this telemedicine system.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

9. This telemedicine system saves me time traveling to hospital or a specialist clinic.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

10. I do receive adequate attention.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree

● Somewhat Agree
● Agree
● Strongly Agree

11. I find this telemedicine system an acceptable way to receive health-care services
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

12. Overall, I am satisfied with the quality of service being provided via this telemedicine system.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

13. Using this telemedicine system enables me to complete my consultation more quickly.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

14. This telemedicine system can improve my access to health care services.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

15. This telemedicine system can help me improve my health.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

16. Using this telemedicine system can make my health care and management easier.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

17. I would find this telemedicine system useful for my health care and management.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

18. Learning to use this telemedicine system is easy for me.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

19. I find it easy to get this telemedicine system to do what I need to do in my health care and management.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree

- Somewhat Agree
- Agree
- Strongly Agree

20. My interaction with this telemedicine system is clear and understandable.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

21. I find this telemedicine system to be flexible to interact with.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

22. It is easy for me to become skillful at using this telemedicine system.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

23. I find this telemedicine system easy to use
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

24. It was simple to use this telemedicine system.
- Strongly Disagree

- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

25. I can effectively complete my mission using this telemedicine system.

- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

26. I can complete my mission quickly using this telemedicine system.

- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

27. I am able to efficiently complete my mission using this telemedicine system.

- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

28. I feel comfortable using this telemedicine system.

- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree

● Strongly Agree

29. It was easy to learn to use this telemedicine system.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

30. I believe I became productive quickly using this telemedicine system.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

31. This telemedicine system gives error messages that clearly tell me how to fix problems.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

32. Whenever I make a mistake using this telemedicine system, I recover easily and quickly.
● Strongly Disagree
● Disagree
● Somewhat Disagree
● Neither Agree nor Disagree
● Somewhat Agree
● Agree
● Strongly Agree

33. The information (help, on-screen messages, tool-tips, etc) provided is clear.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

34. It is easy to find the information I need.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

35. The information provided for this telemedicine system is easy to understand.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

36. The information is effective in helping me complete the tasks and scenarios.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

37. The organization of information on this telemedicine system screen is clear.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree

- Agree
- Strongly Agree

38. The interface of this telemedicine system is pleasant.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

39. I like using the interface of this telemedicine system.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

40. This telemedicine system has all the functions and capabilities I expect it to have.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

41. Overall, I am satisfied with this telemedicine system.
- Strongly Disagree
- Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

42. I am confident about the result I produced.
- Strongly Disagree
- Disagree

- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Agree
- Strongly Agree

43. Mental Demand (How mentally demanding was the task?)

1 (Low) 100 (high)

44. Physical Demand (How physically demanding was the task?)

1 (Low) 100 (high)

45. Temporal Demand (How hurried or rushed was the pace of the task?)

1 (Low) 100 (high)

46. Performance (How successful were you in accomplishing what you were asked to do?)

1 (Low) 100 (high)

47. Effort (How hard did you have to work to accomplish your level of performance?)

1 (Low) 100 (high)

48. Frustration (How insecure, discouraged, irritated, stressed, and annoyed were you?)

1 (Low) 100 (high)

48. What did you like about this telemedicine system?

49. What did you NOT like about this telemedicine system?

Appendix D

Sample questions used for Think-out-loud session

1. Was the content in the invitation email easy to understand?

2. What do you like about the email invitation?

3. What information would you like to have when you receive an email from your care provider?

4. Did you think there was anything confusing in the content?

5. Did you find it challenging to log in to the portal?

6. During the session, could you hear the doctor well?

7. During the session, could you see the doctor well?

8. Could you understand the doctor's commands during the session?

9. Could you find the audio and video toggle icons easily?

10. Were you able to enter the full screen mode easily?

11. Was the chat box convenient to use?

12 Did you get feedback from the chat box when the doctor replied?

13. Could you end the video call with ease?

14. Did you feel this platform was as good as physically visiting with your doctor?

15. Were there any other issues you would like to discuss regarding this telemedicine forum?

16. Do you have any suggestions to improve the system?

Appendix E

Sample Conversations Used

Doxy.me and Vsee

Doctor: Hi. How are you today?

Patient: Good.

Doctor: Welcome to this telemedicine visit. Let's start off by having you change your view to fullscreen so you can see me a little better.

Patient: Okay.

Doctor*:* Before we get started I just want to go over a couple of features of the telemedicine software with you. Can you mute your microphone? When you have it muted say something so I can verify I cannot hear you.

Patient: Ok.

Doctor*:* Ok you can go ahead and unmute it now.

Doctor: Can you try to disable your video now?

Patient: Ok.

Doctor: Ok, you can go ahead and enable it.

Doctor: So, how have you been doing this week?

Patient: -----------------

Doctor: How has your blood sugar levels been?

Patient: -----

Doctor: Did you get a chance to take your blood pressure before our visit?

Patient: Yes, I just took it a minute ago.

Doctor: Great, can you type your most recent blood pressure into the chat box please?

Patient: No problem!

Doctor: Ok, blood pressure is good. Have you been able to exercise at all?

Patient: -----------------

Doctor: Sounds like you're off to a great start. Just remember to keep challenging yourself so that the exercise doesn't get to easy. Do you have any questions for me?

Patient: -------------

Doctor: Of course, don't hesitate to ask if you think of anything. Based on your numbers I think I'd like to see you back in 1 month. Would you like to meet over the telemedicine software again?

Patient: Yes, that works best for me!

Doctor: Ok, we'll be in touch to schedule with you then. Bye!

Patient: Bye!

Polycom

Doctor: Hi. How are you today?

Patient: Good.

Doctor: Welcome to this telemedicine visit. Before we get started I just want to go over a couple of features of the telemedicine software with you. Can you mute your microphone? When you have it muted say something so I can verify I cannot hear you.

Patient: Ok.

Doctor: Ok you can go ahead and unmute it now.

Doctor: Can you try to disable your video now?

Patient: Ok.

Doctor: Ok, you can go ahead and enable it.

Doctor: So, how have you been doing this week?

Patient: -----------------

Doctor: How has your blood sugar levels been?

Patient: -----

Doctor: Did you get a chance to take your blood pressure before our visit?

Patient: Yes, I just took it a minute ago.

Doctor: Great, can you tell me your most recent blood pressure, please?

Patient: No problem!

Doctor: Ok, blood pressure is good. Have you been able to exercise at all?

Patient: -----------------

Doctor: Sounds like you're off to a pretty good start. Just remember to keep challenging yourself so that the exercise doesn't get to easy. Do you have any questions for me?

Patient: -------------

Doctor: Of course, don't hesitate to ask if you think of anything. Based on your numbers I think I'd like to see you back in 1 month. Would you like to meet over the telemedicine software again?

Patient: Yes, that works best for me!

Doctor: Ok, we'll be in touch to schedule with you then. Take care!

Vidyo

Doctor: Hi. How are you today?

Patient: Good.

Doctor: Welcome to this telemedicine visit. Let's start off by having you change your view to fullscreen so you can see me a little better.

Patient: Okay.

Doctor: Before we get started I just want to go over a couple of features of the telemedicine software with you. Can you mute your microphone? When you have it muted say something so I can verify I cannot hear you.

Patient: Ok.

Doctor: Ok you can go ahead and unmute it now.

Doctor: Can you try to disable your video now?

Patient: Ok.

Doctor: Ok, you can go ahead and enable it.

Doctor: So, how have you been doing this week?

Patient: -----------------

Doctor: How has your blood sugar levels been?

Patient: -----

Doctor: Did you get a chance to take your blood pressure before our visit?

Patient: Yes, I just took it a minute ago.

Doctor: Great, can you tell me your most recent blood pressure, please?

Patient: No problem!

Doctor: Ok, blood pressure is good. Have you been able to exercise at all?

Patient: -----------------

Doctor: Sounds like you're off to a pretty good start. Just remember to keep challenging yourself so that the exercise doesn't get to easy. Do you have any questions for me?

Patient: -------------

Doctor: Of course, don't hesitate to ask if you think of anything. Based on your numbers I think I'd like to see you back in 1 month. Would you like to meet over the telemedicine software again?

Patient: Yes, that works best for me!

Doctor: Ok, we'll be in touch to schedule with you then. Take care!

Patient: Bye!

Appendix F

Flyer

Telemedicine System Usability Study
at

Clemson University
352, Fluor Daniel- Engineering Innovation Building

Telemedicine is the use of technology such as computers, smartphones and tablets to access and obtain health services when distance separates doctors and patients.

This study aims to identify usability issues faced by people **above the age of 60 years** in Telemedicine systems. It will involve the usage of a computer to carry out a video call with the researcher and will not have any form of physical exertion. The session will take up **an hour** of your time.

Volunteers will be provided with a **$25 Walmart gift card** as a token of our appreciation for your efforts.
On campus parking permit will also be provided.

REFERENCES

Agnisarman, S. O., Chalil Madathil, K., Smith, K., Ashok, A., Welch, B., & McElligott, J. T. (2017/1). Lessons learned from the usability assessment of home-based telemedicine systems. *Applied Ergonomics*, *58*, 424–434.

Bashshur, R. L., Reardon, T. G., & Shannon, G. W. (2000). Telemedicine: a new health care delivery system. *Annual Review of Public Health*, *21*, 613–637.

Bevan, N. (2003). UsabilityNet methods for user centred design. *Human-Computer Interaction: Theory and Practice*, *1*. Retrieved from https://books.google.com/books?hl=en&lr=&id=s6YW-cZBTqwC&oi=fnd&pg=PA434&dq=bevan+usability+2003&ots=TY8EcRVUOd&sig=LJkQXrhtaQCUousTMEYAndk8LL0

Brignell, M., Wootton, R., & Gray, L. (2007). The application of telemedicine to geriatric medicine. *Age and Ageing*, *36*(4), 369–374.

Chalil Madathil, K., & Greenstein, J. S. (2011). Synchronous Remote Usability Testing: A New Approach Facilitated by Virtual Worlds. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2225–2234). New York, NY, USA: ACM.

Chalil Madathil, K., Greenstein, J. S., Neyens, D. M., Juang, K., & Gramopadhye, A. K. (2013). An investigation of the informational needs of ovarian cancer patients and their supporters. In *Proceedings of the Human Factors and Ergonomics Society's International Annual Meeting, San Diego, CA*.

Coelho, K. R. (2011). Identifying telemedicine services to improve access to specialty care for the underserved in the san francisco safety net. *International Journal of Telemedicine and Applications*, *2011*, 523161.

Corcoran, H., Hui, E., & Woo, J. (2003). The acceptability of telemedicine for podiatric intervention in a residential home for the elderly. *Journal of Telemedicine and Telecare*, *9*(3), 146–149.

Couturier, P., Tyrrell, J., Tonetti, J., Rhul, C., Woodward, C., & Franco, A. (1998). Feasibility of orthopaedic teleconsulting in a geriatric rehabilitation service. *Journal of Telemedicine and Telecare*, *4*(suppl 1), 85–87.

Czaja, S. J., Lee, C. C., Arana, N., Nair, S. N., & Sharit, J. (2014). Use of a telehealth system by older adults with hypertension. *Journal of Telemedicine and Telecare*, *20*(4), 184–191.

Czaja, S. J., Zarcadoolas, C., Vaughon, W. L., Lee, C. C., Rockoff, M. L., & Levy, J. (2015). The usability of electronic personal health record systems for an underserved adult population. *Human Factors*, *57*(3), 491–506.

Demiris, G., Finkelstein, S. M., & Speedie, S. M. (2001). Considerations for the design of a Web-based clinical monitoring and educational system for elderly patients. *Journal of the American Medical Informatics Association: JAMIA*, *8*(5), 468–472.

Faulkner, L. (2003). Beyond the five-user assumption: benefits of increased sample sizes in usability testing. *Behavior Research Methods, Instruments, & Computers: A Journal of the Psychonomic Society, Inc*, *35*(3), 379–383.

Grosch, M. C., Weiner, M. F., Hynan, L. S., Shore, J., & Cullum, C. M. (2015). Video teleconference-based neurocognitive screening in geropsychiatry. *Psychiatry Research*, *225*(3), 734–735.

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. In Peter A. Hancock and Najmedin Meshkati (Ed.), *Advances in Psychology* (Vol. Volume 52, pp. 139–183). North-Holland.

Hui, E., Woo, J., Hjelm, M., Zhang, Y. T., & Tsui, H. T. (2001). Telemedicine: a pilot study in nursing home residents. *Gerontology*, *47*(2), 82–87.

Hu, P. J., Chau, P. Y. K., Liu Sheng, O. R., & Tam, K. Y. (1999). Examining the Technology Acceptance Model Using Physician Acceptance of Telemedicine Technology. *Journal of Management Information Systems*, *16*(2), 91–112.

Izquierdo, R. E., Knudson, P. E., Meyer, S., Kearns, J., Ploutz-Snyder, R., & Weinstock, R. S. (2003). A comparison of diabetes education administered through telemedicine versus in person. *Diabetes Care*, *26*(4), 1002–1007.

Jasemian, Y. (2008). Elderly comfort and compliance to modern telemedicine system at home. In *2008 Second International Conference on Pervasive Computing Technologies for Healthcare* (pp. 60–63).

Jennett, P. A., Affleck Hall, L., Hailey, D., Ohinmaa, A., Anderson, C., Thomas, R., … Scott, R. E. (2003). The socio-economic impact of telehealth: a systematic review. *Journal of Telemedicine and Telecare*, *9*(6), 311–320.

Kang, H. G., Mahoney, D. F., Hoenig, H., Hirth, V. A., Bonato, P., Hajjar, I., … Center for Integration of Medicine and Innovative Technology Working Group on Advanced Approaches to Physiologic Monitoring for the Aged. (2010). In situ monitoring of health in older adults: technologies and issues. *Journal of the American Geriatrics Society*, *58*(8), 1579–1586.

Kobb, R., Nannette, H., Robert, L., & Sheri, K. (2003). Enhancing Elder Chronic Care through Technology and Care Coordination: Report from a Pilot. *Telemedicine Journal and E-Health: The Official Journal of the American Telemedicine Association*, *9*(2), 189–195.

Koch, S. (2006). Home telehealth--current state and future trends. *International Journal of Medical Informatics*, *75*(8), 565–576.

Lamothe, L., Fortin, J.-P., Labbé, F., Gagnon, M.-P., & Messikh, D. (2006). Impacts of telehomecare on patients, providers, and organizations. *Telemedicine Journal and E-Health: The Official Journal of the American Telemedicine Association*, *12*(3), 363–369.

Lewis, C. H. (1982). Using the" thinking Aloud. *Method In Cognitive Interface Design*.

Lewis, J. R. (1995). IBM computer usability satisfaction questionnaires: Psychometric evaluation and instructions for use. *International Journal of Human-Computer Interaction*, *7*(1), 57–78.

Lustig, T. A., & Others. (2012). *The role of telehealth in an evolving health care environment: workshop summary*. National Academies Press.

Madathil, K. C., Alapatt, G. F., & Greenstein, J. S. (2010). An Investigation of the Usability of Image-based CAPTCHAs. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 54, pp. 1249–1253). SAGE Publications.

Madathil, K. C., Koikkara, R., Dorlette-Paul, M., Ranganayakulu, S., Greenstein, J. S., & Gramopadhye, A. K. (2012). An investigation of format modifications on the comprehension of information in consent form when presented on mobile devices. *Proceedings of the Human Factors and Ergonomics Society ... Annual Meeting Human Factors and Ergonomics Society*. *Meeting*, *56*(1), 921–925.

Makai, P., Perry, M., Robben, S. H. M., Schers, H. J., Heinen, M. M., Olde Rikkert, M. G. M., & Melis, R. F. (2014). Evaluation of an eHealth intervention in chronic care for frail older people: why adherence is the first target. *Journal of Medical Internet Research*, *16*(6), e156.

Matusitz, J., & Breen, G.-M. (2007). Telemedicine: its effects on health communication. *Health Communication*, *21*(1), 73–83.

Merrell, R. C. (2015). Geriatric Telemedicine: Background and Evidence for Telemedicine as a Way to Address the Challenges of Geriatrics. *Healthcare Informatics Research*, *21*(4), 223–229.

Merrell, R. C., & Doarn, C. R. (2015). Geriatric Telemedicine. *Telemedicine and E-Health*, *21*(10), 767–768.

Militello, L. G., & Hutton, R. J. (1998). Applied cognitive task analysis (ACTA): a practitioner's toolkit for understanding cognitive task demands. *Ergonomics*, *41*(11), 1618–1641.

Narasimha, S., Agnisarman, S., Madathil, K. C., Gramopadhye, A. K., Welch, B., & Mcelligott, J. (2016). An Investigation of the Usability Issues of Home-based Video Telemedicine Systems with Geriatric Patients. *Proceedings of the Human Factors and Ergonomics Society ... Annual Meeting Human Factors and Ergonomics Society. Meeting*, *60*(1), 1804–1808.

Narasimha, S., Agnisarman, S.O., Roger, H., Chalil Madathil, K., Welch, B., Ashok, A., Nair, A. & McElligott, J.T. (2016). Designing Telemedicine Systems for Geriatric Patients: A Review of the Usability Studies. *Telemedicine Journal and E-Health: The Official Journal of the American Telemedicine Association*.

Pak, R., & McLaughlin, A. (2010). *Designing Displays for Older Adults*. CRC Press.

Pallawala, P. M., & Lun, K. C. (2001). EMR based telegeriatric system. *International Journal of Medical Informatics*, *61*(2-3), 229–234.

Parker Oliver, D. R., Demiris, G., & Porock, D. (2005). The usability of videophones for seniors and hospice providers: a brief report of two studies. *Computers in Biology and Medicine*, *35*(9), 782–790.

Poon, P., Patricia, P., Elsie, H., David, D., Timothy, K., & Jean, W. (2005). Cognitive intervention for community-dwelling older persons with memory problems: telemedicine versus face-to-face treatment. *International Journal of Geriatric Psychiatry*, *20*(3), 285–286.

Santos, D. F. S., Almeida, H. O., & Perkusich, A. (2015/5). A personal connected health system for the Internet of Things based on the Constrained Application Protocol. *Computers & Electrical Engineering*, *44*, 122–136.

Schofield, R. S., Kline, S. E., Schmalfuss, C. M., Carver, H. M., Aranda, J. M., Jr, Pauly, D. F., … Chumbler, N. R. (2005). Early outcomes of a care coordination-enhanced telehome care program for elderly veterans with chronic heart failure. *Telemedicine Journal and E-Health: The Official Journal of the American Telemedicine Association*, *11*(1), 20–27.

Sene, A., Kamsu-Foguem, B., & Rumeau, P. (2015). Telemedicine framework using case-based reasoning with evidences. *Computer Methods and Programs in Biomedicine*, *121*(1), 21–35.

Shah, M. N., Wasserman, E. B., Wang, H., Gillespie, S. M., Noyes, K., Wood, N. E., … McConnochie, K. M. (2016). High-Intensity Telemedicine Decreases Emergency Department Use by Senior Living Community Residents. *Telemedicine Journal and E-Health: The Official Journal of the American Telemedicine Association*, *22*(3), 251–258.

Stronge, A. J., Rogers, W. A., & Fisk, A. D. (2007). Human factors considerations in implementing telemedicine systems to accommodate older adults. *Journal of Telemedicine and Telecare*, *13*(1), 1–3.

Vermeersch, P., Sampsel, D. D., & Kleman, C. (2015). Acceptability and usability of a telepresence robot for geriatric primary care: A pilot. *Geriatric Nursing*, *36*(3), 234–238.

Virzi, R. A. (1992). Refining the Test Phase of Usability Evaluation: How Many Subjects Is Enough? *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *34*(4), 457–468.

Wang, H., Jafari, R., Zhou, G., Venkatasubramanian, K. K., Sun, J. S., Bonato, P., & Wu, D. (2015). Guest Editorial: Special Issue on Internet of Things for Smart and Connected Health. *IEEE Internet of Things Journal*, *2*(1), 1–4.

Wiborg, A., Widder, B., & Telemedicine in Stroke in Swabia Project. (2003). Teleneurology to improve stroke care in rural areas: The Telemedicine in Stroke in Swabia (TESS) Project. *Stroke; a Journal of Cerebral Circulation*, *34*(12), 2951–2956.