Evaluating Usability, Effectiveness, and Usage

of Telehealth Technologies

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To:

First and foremost, to my mom and dad, Zorica and Alija, who taught me to never stop learning. They showed me the values and importance of education and that learning does not stop behind the formal school doors.

To my husband Selen, who stood by me through all these years of juggling school, work, and a young family. He has taught me that women CAN have it all.

To the two quirkiest and most beautiful kids I know – Linn and Milla. This one is for you kiddos, to stay strong and be the unique persons that you are, and always, always pursue your dreams.
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ABSTRACT

BACKGROUND: Affordable Care Act (ACA) has allowed more patients that did not previously have health care insurance to have coverage and access to care. This increase in the number of patients seeking medical care will only add additional stress to the existing disproportion of supply of and demand for health care providers. In addition, rising health care costs have major effect on how, where, and even if consumers will get needed care.

Missouri is a largely rural state directly affected by the aforementioned changes in health care. Rural population has limited access to specialty care, which can get even more difficult in winter months.

AIMS: This study examined three different telehealth platforms in three different medical specialties in order to evaluate the perception that they would be appropriate vehicles for increasing access to care. We also wanted to find out what the users’ perceptions of these technologies are, as that can be a driving factor in adoption of new technologies.

METHODS: This research included three separate studies. The first study examined the usability and acceptance of a new mobile application in teledermatology clinics. The second study focused on usability and acceptance of ICU Robots in a medical ICU. Finally, the third study evaluated if children and youth currently using telepsychiatry as a care delivery method would have other in-person options if telehealth was not available.
RESULTS: These studies have shown that these different telehealth technologies are tools that are easy to use, and that they are also acceptable methods for health care delivery. The mHealth app was perceived as a much more favorable device compared to the previous method for picture sharing between clinics and specialists. Similarly, the ICU Robot was found to be an acceptable tool for providers not physically present, although the providers not trained on how to use it seemed somewhat detached and disengaged during our study. In addition, telehealth helps with access to care for the rural Missouri population, such as children and adolescents accessing psychiatry services via telehealth.

CONCLUSION: Missouri has a robust telehealth network that provides technical support for clinical and non-clinical telehealth usage. Over the years, the network has grown from a 2-site to a 160-site program. The results of this study can help identify future steps for growth and type of equipment for investment in order to improve services further and increase access to care. In addition, provider perceptions and opinions can assist with planning training and protocols.
CHAPTER 1: INTRODUCTION

Overview

One of the main workforce challenges of health care in the US today is physician shortage and distribution. It is predicted that this maldistribution crisis will only worsen in the upcoming years\(^1\). The Association of American Medical Colleges issued a statement addressing this issue, and concluded that the physician workforce shortage will culminate in the upcoming years and decades unless one of the two, or both, following changes happen: 1) fundamental changes in the demand/supply for health care, and 2) the way healthcare is provided\(^2\). While many analyses and discussions focus on the shortage of primary care physicians, the lack of access to specialists for rural and underserved population is even more severe. Only about 10% of physicians practice in rural areas, while one fourth of the population lives in those areas\(^3\).

Currently, there are 62 million people living in rural areas in the US\(^3\). Rural residents tend to have poorer health outcomes due to various socio-economic causes. In addition, more people in rural areas live in poverty than in urban areas\(^3\). This makes them more at risk for not seeking timely health care, or not having means to receive health care in the first place\(^4,5,6,7\). Rural areas have almost three times as many Health Professional Shortage Areas (HPSA) than urban areas\(^3\). Rural 12\(^{th}\) graders are almost twice as likely to drink and drive, and smoke cigarettes, as urban 12\(^{th}\) graders\(^3\).

Missouri Specific Overview

The state of Missouri is a largely rural state: only 14 counties are considered urban, while 101 counties fall under the rural category\(^8\). Almost 40 percent of the population lives in these rural areas, which cover about 90 percent of the total Missouri land\(^8,9\). Although the
population in rural Missouri is not as racially diverse as in urban areas, there are still many language and cultural challenges the rural population faces. Almost 4 percent of rural Missouri residents speak language other than English, and over 40 percent of them do not speak English ‘very well’.

Poverty in rural Missouri is 24 percent higher than in urban Missouri. While rural residents’ poverty rate is 18 percent, it is only 14 percent in urban areas. Another alarming fact is that poverty rates for children under 18 in rural areas are 32 percent higher than in urban areas. There are eight rural counties with children poverty rates above 40 percent.

There are two striking differences between rural and urban population: while death from all causes are significantly higher in rural population than urban, urban population has higher hospitalization rates than rural. It can be argued that lack of appropriate and affordable healthcare is one of the reasons for rural population not being able to seek timely care.

**Solution 1 to Increase Access to Care: Changes in Graduate Medical Education and Medical Residency**

In 2008, the National Rural Health Association and the American Academy of Family Physicians issued a joint statement that addressed the fact that medical education in the United States “has become specialized, centralized and urban [...]” and “as a result, [...] a challenge to remain relevant to the needs of [...] small communities”. Both of these organizations have supported, over the years, endeavours that promote and fund programs addressing rural provider shortage. There are three major interventions that have taken effect in the last few years:
a) Medical schools make conscious efforts, through newly established policies, to admit students with rural backgrounds who will be more likely to return and practice in rural areas.

b) Rural track pipeline programs that attract and retain students to intern and then practice in rural areas.

c) New programs in medical school specially designed for rural health practices. Students with rural backgrounds are more likely to practice in rural areas, when compared with students with urban backgrounds\textsuperscript{10,11,12, 13}. In addition, students with rural training experiences tend to consider a variety of rural practices\textsuperscript{11}.

Quinn emphasized that “curriculum changes can help students obtain more exposure to rural medicine”\textsuperscript{11}. How prepared the students are to live and practice in rural areas also highly depends on this exposure, especially for students with urban backgrounds\textsuperscript{11}.

In order to meet the medical needs of the both rural and urban population by having an adequate number of practicing physicians in all locations, it is essential to increase the number of medical residency slots, according to the American Medical Association\textsuperscript{12}. However, it is also necessary to implement major innovations in medical education to address the workforce needs\textsuperscript{12}.

**Solution 2 to Increase Access to Care: Telehealth**

Various health care information technologies (IT), such as electronic medical records, Picture Archiving and Communication System (PACS), and telehealth, are undergoing major changes to make them more affordable and easier to use. Over the last two decades,
telehealth equipment has evolved from a $50,000 video camera and television set up, to a mobile device with high definition (HD) software costing roughly $2,000.

Reports indicate the potential telehealth has in addressing a few major health care challenges today, such as: a) decreased supply of physicians, b) increased demand for care, c) rising health care costs, d) increased demand for mobility. It shows improved access to care, while patients’ adherance to care increases and providers are able to consult and network from different locations.

Sandberg et al learned that, in diabetes case management, telemedicine allowed for two major improvements: 1) the ability to include family members, and 2) the ability to provide services to underserved elderly, who face real barriers to care. In addition, providers who initially were not comfortable using video-conferencing to provide services to their patients reported being ‘pleasantly surprised’ by the quality of the provider-patient relationships they built, and that they changed their opinions regarding telehealth.

Although there are still challenges with this model of healthcare delivery, such as reimbursement and policy initiatives, telehealth leverages and can improve rural health outcomes, and has the “potential to revolutionize rural health care”. American Telemedicine Association estimates that more than half of the US hospitals use some form of telemedicine today, with about 200 networks connecting 3,000 rural sites to large urban specialty medical centers.

**Purpose of Study**

This study focuses on Solution 2 to increase access to care – telehealth. By studying current usage and acceptance of different technologies used to provide services over distance, I
want to learn if this solution is an acceptable model to increase care to rural and underserved areas, and one that is worth investment by providers and health care organizations.

There has been a plethora of research on telehealth conducted in the past 40 years, with Medline indexing over 10,000 citations to date\textsuperscript{18}. This research can be grouped into three categories – cost effectiveness of telehealth, telehealth and quality of care, and patient satisfaction\textsuperscript{18}. While all three categories are of the utmost importance for development and growth of services, there is clearly a lack of data on provider acceptance and usage of telehealth technologies. Since the success of any telehealth program appears to be very provider-centric, it is essential to examine the effectiveness and usefulness of these technologies as perceived by providers. In other words, if there is no provider champion, the telehealth program may not succeed, in spite of the need for services.

The ultimate purpose of this research is to examine the usefulness and effectiveness of telehealth. I will do so by evaluating adoption of mHealth in teledermatology, robotics in ICU, and traditional video conferencing in child and adolescent psychiatry. The purpose of this research is also to improve access to specialty care in rural areas, and increase usage of telehealth technologies in an academic hospital. This research focuses primarily on human-computer interaction, and examines perceptions, attitudes, usage, and opportunities of different telehealth technologies in three different healthcare specialties.

**Goal:** Characterize and describe specific telehealth tools used in a specialty clinic and/or inpatient unit. Evaluate usefulness and effectiveness, as well as provider attitudes and perceptions, of corresponding technology.
Research question 1.

a) Will mHealth be adopted in teledermatology clinics? Can mHealth replace traditional teledermatology picture-viewing technology?

Research question 2.

a) Is robotic telepresence in ICU an appropriate tool for seeing patients when used internally vs. outsourcing?

Research question 3.

a) Do children and adolescents using tele-psychiatry services have other in-person options to get this specialty care?

Research Design

Usability and effectiveness of technologies can be measured in different ways: some studies used the fit between individual, task, and technology (FITT) framework, or think-aloud protocol combined with a questionnaire that describes usability. For my study, I have adopted a model that examines usability and effectiveness through adoption and usage of different telehealth technologies. It is my belief that studying only one telehealth modality in one specialty setting would not give us the best overview of usefulness and acceptance; therefore, it would be harder to answer the question of whether or not telehealth can be used as an appropriate tool to aid health care crises in rural and underserved areas. For the purpose of this research, and to understand better the overall impact, I developed and adopted the research design that is specific to adoption of IT technologies in health care and social sciences.
The proposed three studies are applied research studies in the area of health and medical informatics. Information technology (IT) research often focuses on installation and implementation, but rarely on users’ reaction and perceptions of IT systems\textsuperscript{20,21,22,23,24}. However, IT success cannot be measured solely on the design and implementation, but on other matrices as well – functionality, usefulness, effectiveness, user perception, capability, etc.\textsuperscript{24}. Healthcare organizations need to have a good understanding of what these elements are, and then use that knowledge to adjust and control them, in order to increase acceptance and usage of telehealth\textsuperscript{24}.

In order to assess the usefulness and effectiveness of telehealth technologies adequately, I focused conceptually on the Technology Acceptance Model (TAM) Theory, and grounded theory. So far, TAM has been considered to be a premier theory for Health IT; however, it is presumed it will to grow into the theory of Health IT, as the current interest and success in health IT grows\textsuperscript{19}. Similarly, the grounded theory approach to read, re-read, and study text and data allows for identification of categories and specific answers coming from the questionnaires and study surveys.

The TAM Theory claims that the acceptance of IT – measured by asking providers questions about their use and intentions to use the specific technology – is a key to growth and increased usage\textsuperscript{19} (Figure 1). In our study, we will focus on the perceived usefulness and effectiveness, as well as current usage of telehealth, to help us understand the usage trends.
Another research model that combines the TAM theory and Diffusion of Innovations (RI) Theory is shown in Figure 2, and it analyzes the reasons affecting the providers’ decision to use telehealth technologies. This model, with some adaptation to exclude the attitude construct and include situational support, is a solid basis for understanding the relationship between various factors affecting the intention to adopt, and the actual adoption, of telehealth systems.
TAM and RI theories focus on providers’ perceived intention and persistence before the actual adoption of telehealth technologies. Researchers have shown that there is a direct link between perceived usefulness and their intention to use telehealth technologies; Croteau and Vieru \(^ {24} \) tested and showed this link.

The central aspect of these two models is that they emphasize the importance of how the users themselves shape actual practices. In other words, while an organization may invest in purchasing and implementing IT technologies, concrete usage will depend on the perception and opinions from actual users. While this approach has been somewhat researched with the adoption of electronic medical records (EMRs), there is not enough data on adoption of telehealth.

The TAM theory model was used as a conceptual framework for the mHealth study. This is because user acceptance of IT among physicians differs from other professionals, administrative personnel, and students \(^ {25} \). One of the reasons is that medical professionals “enjoy more professional status than almost any other profession” \((p. 3)\) \(^ {25} \). While the monopoly over medical knowledge may have been justified in the past, in order to justify exclusive license to practice, it is no longer the case \(^ {25} \). Today, with the increasing healthcare costs, shortage of both primary care and specialty physicians, and increasing demand for health care services, health care organizations and providers are looking for ways to provide needed services at a lower cost and to all patient populations.

Grounded theory has been used succesfully when evaluating the impact of health information systems in healthcare \(^ {26} \). It is particularly useful when trying to describe general
patterns and rules of difference\textsuperscript{27,28}. While some researchers rely on answer-coding to group and cluster the answers in search for specific patterns, others use this theoretical framework as a guidance to structure their questions and/or interviews.

Studying healthcare organizations and healthcare providers utilizing telehealth technologies is a complex phenomenon that falls within the information sciences section of socio-technical emphasis\textsuperscript{29}. It has been argued that researchers must adopt a new methodology, in fact, using the grounded theory as a basis for data collection and analyses\textsuperscript{29}.

### Table 1: Key differences in GTM approach, Onions, 2006

<table>
<thead>
<tr>
<th>‘Glaserian’</th>
<th>‘Straussian’</th>
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<tr>
<td>Beginning with general wonderment (an empty mind)</td>
<td>Having a general idea of where to begin</td>
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<td>Emerging theory, with neutral questions</td>
<td>Forcing the theory, with structured questions</td>
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<tr>
<td>Development of a conceptual theory</td>
<td>Conceptual description (description of situations)</td>
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<tr>
<td>Theoretical sensitivity (the ability to perceive variables and relationships) comes from immersion in the data</td>
<td>Theoretical sensitivity comes from methods and tools</td>
</tr>
<tr>
<td>The theory is grounded in the data</td>
<td>The theory is interpreted by an observer</td>
</tr>
<tr>
<td>The credibility of the theory, or verification, is derived from its grounding in the data</td>
<td>The credibility of the theory comes from the rigour of the method.</td>
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<tr>
<td>A basic social process should be identified</td>
<td>Basic social processes need not be identified</td>
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<tr>
<td>The researcher is passive, exhibiting disciplined restraint</td>
<td>The researcher is active</td>
</tr>
<tr>
<td>Data reveals the theory</td>
<td>Data is structured to reveal the theory</td>
</tr>
<tr>
<td>Coding is less rigorous, a constant comparison of incident to incident, with neutral questions and categories and properties evolving. Take care not to ‘over-conceptualise’, identify key points</td>
<td>Coding is more rigorous and defined by technique. The nature of making comparisons varies with the coding technique. Labels are carefully crafted at the time. Codes are derived from ‘micro-analysis which consists of analysis data word-by-word’</td>
</tr>
<tr>
<td>Two coding phases or types, simple (fracture the data then conceptually group it) and substantive (open or selective, to produce categories and properties)</td>
<td>Three types of coding, open (identifying, naming, categorising and describing phenomena), axial (the process of relating codes to each other) and selective (choosing a core category and relating other categories to that)</td>
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<td>Regarded by some as the only ‘true’ GTM</td>
<td>Regarded by some as a form of qualitative data analysis (QDA)</td>
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Grounded theory can broadly be divided into two different approaches: Glaserian and Straussian (Figure 1). The Glaserian approach uses constant comparisons between incidents, and allows a researcher to study events without a theory to prove, or disprove\textsuperscript{30}. Once data collection is completed, coding and analysis of the data takes place; however, the Glaserian
method is not as much interested in what is going on with the data, but with understanding the concept being discussed. Analysis usually consists of identifying key ideas in the collected data, and then sorting them into categories or properties. In addition, literature review is not necessarily done prior to research; rather, it is completed upon the data collection. Strauss’ approach to qualitative research, although very similar to Glaserian’s, has a few very different stances. One, researcher should identify early on what path they want to take in their research. In other words, they can use literature review to shape their knowledge about the subject and form ideas about identifying the phenomenon they want to study. The danger with this approach, especially for the novice researcher, is that often they can confirm the existing knowledge, rather than discover new.

For my research, I focused on the Glaserian approach (Table 1) of the GTM. This model allowed me to have a more open-minded approach to my research. Although telehealth and its technologies are not new, their usage in healthcare has not been studied in depth. I have used the Glaserian model as a basis of my research, which allowed me to find out if certain technologies work better than others, and what attitudes the users have towards telehealth. It was important for me not to conform to data that are already available or be influenced by other findings, and instead come to new conclusions.

Definitions

Telehealth – the use of electronic information and telecommunications technologies to support long-distance clinical health care, patient and professional health-related education, public health, and health administration.
Telemedicine – the use of medical information exchanged from one site to another via electronic communications to improve a patient’s clinical health status.34

eHealth – emerging field at the intersection of medical informatics, public health, and business, referring to health services and information delivered or enhanced through Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology.35

mHealth – an area of eHealth that provides health services and information via mobile technologies such as mobile phones and PDAs. mHealth can also support the performance of health care workers by the dissemination of clinical updates, learning materials, and reminders.36

Live interactive video – type of digital video that supports user interaction.37

Store-and-Forward telemedicine – use of asynchronous (not real-time) computer-based communication between a patient and a consulting provider, or a referring provider and a medical specialist for the purpose of diagnostic and therapeutic assistance.37

Telemonitoring – use of information technology to monitor patients at a distance.38

Rural – areas of less than 50,000 people.39

Urban – areas of 50,000 or more people.40
Metropolitan statistical area – a core urban area of 50,000 or more people that consists of one or more counties containing the urban area and any adjacent counties that have a high degree of social and economic integration.  

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CHAPTER 2: LITERATURE REVIEW

A current review of literature on telehealth can be grouped into the following categories: a) provider and patient satisfaction with telehealth, b) evaluation of home health technology usage, c) application of robotics in critical care setting, d) evaluation of eHealth and mHealth applications in health care. Home health telehealth is one of the largest consumer-based telehealth usages today, still very limited by reimbursement options. Similarly, robotics in critical care have shown remarkable improvements in patient outcomes, but this type of inpatient video-conferencing is a service- or mission-driven method of care delivery. The other two main groups of research areas in telehealth, user satisfaction, and mHealth and eHealth technologies, are both significant because of the ever-changing technologies and their application in health care. In order to keep up with the advancements, we must not only examine the types of equipment and connections used, but also how they are perceived by users in specific settings.

Provider and Patient Satisfaction with Telehealth

The feasibility of telehealth technologies is often measured by evaluating the satisfaction of providers and patients with this type of technology. In general, studies have shown high patient satisfaction with telehealth. Mair et al report that patients in remote areas without appropriate access to care see telehealth as an opportunity to access specialist care, and that it would also save them hospital admissions. Liu also reports high patient satisfaction with telehealth encounters, but this study found physicians’ dissatisfaction with the technology they perceived as creating a
communication barrier\textsuperscript{43}. These findings seem to be isolated, as other studies on provider satisfaction showed positive opinions and high acceptance\textsuperscript{44}.

A majority of patients with chronic diseases using telehealth to see specialists do not feel that their relationship with the physician is affected in any way when not seeing them in person\textsuperscript{45}. Differences in opinions between physicians and patients reported by Liu can be viewed in the context of the complexity of the interpersonal relationship between providers and patients in healthcare\textsuperscript{43}. Onor et al argued that this relationship is, in fact, one of the most complex ones, as patients and providers are “... not on the same level, [the relationship] is not sought by both individuals, it is emotionally loaded, and it requires mutual co-operation toward a shared goal.” (p. 102-3)\textsuperscript{46}

Evaluation of Home Health Technologies and Usage

Patients that continue using telehealth home monitoring after formal homecare to manage heart failure show greater improvement than the control group\textsuperscript{47}. In addition, patients that continued to use telehealth during this study did not have any emergency department visits or hospitalizations, while the control group had 28% ED visits and 26% hospitalization\textsuperscript{47}.

In addition to improved patient outcomes, it has been reported that implementing telehealth in home health agencies can have a positive impact on financial effectiveness, by reducing nurses’ travel time and costs, and allowing more patients to be monitored during each shift\textsuperscript{48}. Home health agency’s daily census can be increased 40%-90% by using a telehealth system\textsuperscript{49}.

Some forms of home-health technologies, such as a pendant alarm required to be monitored both by patient and remote nursing staff, was found to be an ineffective tool for
safe patient monitoring\textsuperscript{50}. One of the main reasons was a low patient reading ability of the monitor, which was, interestingly, found not to be affected by the fact that patients had or did not have an in-home caregiver who helped with the monitor reading\textsuperscript{50}. Wade reported the importance of remote nurse monitoring such patients, regardless of patient’s ability or presence of the in-home caregiver\textsuperscript{50}.

In conclusion, home care systems have to be examined carefully, in order to be developed successfully. There are four main categories: human components, information communication technology components, operational units, and support elements\textsuperscript{51}. Patient centered-care is the future of health care, and home health not only can save money and time, but increase timely access to care and reduce recovery time for critical patients\textsuperscript{52}.

**Application of Robotics in Critical Care**

It is estimated that, in 2010, there were 25 North American ICUs using a total of 56 remote presence robots, and they were mostly used by senior physicians in mature programs, providing decentralized telehealth services to remote and rural areas. All of the users in this study (100\%) believed that patient care had improved since the implementation of remote presence robots\textsuperscript{53}. Another study on patient satisfaction with ICU Robots found that over 90\% of the patients and their families were comfortable with the Robot, and supported continued use\textsuperscript{54}. Similarly, the use of ICU Robots for after-hour care was associated with improved critical care nursing satisfaction\textsuperscript{55}.

Although there seems to be a relatively high acceptance rate of robotic telepresence by providers and patients, especially in ICU and emergency health care settings, there are quite a few barriers for adoption of this kind of system\textsuperscript{56}. In addition to high costs of robotic
telepresence equipment and limited or lack of reimbursement, providers expressed concerns regarding licensure, credentialing, and malpractice protection\textsuperscript{56}. In many cases, the latter concerns are a matter of provider and organization education in telemedicine, as they are specific guidelines and regulations that address these three concerns. In many cases, licensure, credentialing, and malpractice do not pose as obstacles, when understood and carried out according to the said guidelines.

**Evaluation of eHealth and mHealth**

The last ten years have marked a significant growth of mHealth as a part of a larger eHealth domain\textsuperscript{57}. Mobile applications are particularly interesting and useful when targeting very specific needs of a population\textsuperscript{57}. The availability of mHealth suggests health care can be accessed and delivered anytime and anywhere\textsuperscript{58}.

The cost-saving benefits for eHealth and mHealth are still being investigated; however, initial research reveals improved patient access to care, as well as reduced costs for specific services\textsuperscript{59}. Schweitzer also points out the need to examine a wider range of eHealth and mHealth usage in order to draw final conclusions regarding economic benefits for organizations and providers.

One of the main advantages of mHealth is, in part, the ability to use wireless services and networks, versus a more costly broadband method of interacting between parties. While this is becoming less of an issue in the United States, where even the most remote areas now have access to affordable broadband, many third-world countries do not have the same services readily available. On the other hand, wireless networks are accessible worldwide. This
allows eHealth technologies to spread, not only through the metropolitan areas, but also remote villages globally⁶⁰.
CHAPTER 3: MOBILE TECHNOLOGY APPLICATIONS FOR INTERACTIVE DIAGNOSES IN TELEDERMATOLOGY CLINIC

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Abstract
Over the past two decades, teledermatology has typically applied a hybrid model with both live-interactive and store-and-forward imaging technology during the diagnosis process. The primary challenges for teledermatology are integrations of diagnostic information and images captured by heterogeneous digital cameras used by the far sites, image sharing tools by the dermatologists and patients, and means for longitudinal diagnosis of skin diseases. These challenges not only cause disruptive clinic flow, but also limit the capability for the efficacy of diagnoses. The objectives of this study are to adapt mobile applications from in-person clinical to telehealth settings, and evaluate and compare its usability, effectiveness, and changes in clinic flow.

Keywords—telehealth, telemedicine, dermatology, mHealth, store-and-forward.

Introduction
In the current practice of dermatology, about 85% of providers capture digital images of patients at least occasionally, and about 20% obtain images from all of their patients. For dermatology clinics that provide telehealth services, almost all teledermatology is done using image-based technologies, making reliable image capture tools a necessity. In the United States, teledermatology has been used to improve access to care in rural and medically underserved
areas\textsuperscript{4}. However, for telemedicine to be successful, it must be clinically effective, with easy access and visualization of store-and-forward images and an increased level of image quality\textsuperscript{5}.

Although there have been several studies evaluating store-and-forward teledermatology\textsuperscript{6,7,8,9}, as well as patient and provider satisfaction with telehealth\textsuperscript{10,11,12,13}, we found that mobile applications in dermatology are still in their infancy, and there is a great need to assess and evaluate their effectiveness.

**Background**

Nearly 90% of the state of Missouri is rural, with about 40% of the population living in rural areas\textsuperscript{8,9}. Access to specialty care for these residents is limited, because most of the rural clinics do not have specialists on site, and travel to urban hospitals and specialty clinics can be very costly. In order to bridge health disparities and increase access to care for rural residents, the Department of Dermatology at the University of Missouri (MU) has provided telehealth services to patients via the Missouri Telehealth Network (MTN) since 1995. Each year, through the MTN, hundreds of patients remotely see dermatologists at MU via telehealth. The clinic uses a hybrid telehealth model, with both live-interactive video via the Polycom system and store-and-forward images. This hybrid model has been empirically proven successful in providing patients timely access to quality care. However, the digital cameras are cumbersome, due to limited flexibility to provide necessary functions that are commonly seen in mobile applications, and the tedious process to switch input between camera (still images) and the Polycom system (real-time video) during diagnosis. Moreover, the images are deleted from the far site without depositing them into an image repository for long-term storage and future diagnoses.
There are several challenges that have been identified through observations of teledermatology clinics. For instance, physicians rely on presenters from the far sites to switch between patients’ pictures and video with no control over the digital camera. This lengthens patients’ appointments by having to provide instructions to the patient presenter. While viewing images on the screen, the dermatologist is unable to see the patient – making the visit impersonal, while the patient is unable to see their own image when watching the video – limiting the ability to educate the patient regarding their skin condition. Additionally, in contrast to the radiology community, which has had picture archiving and communication systems (PACS) for decades, dermatology is lacking proper image management systems to help dermatology providers organize images collected at both local and far site clinics. Therefore, these challenges motivated the design and development of mHealth and eHealth solutions to meet the needs of dermatologists in clinical practices, research, and education.

mHealth and eHealth solutions are critical to successful practices, as the adoption of mobile technology is on the rise. A recent study identified 79 apps specific to dermatology that can be reached through a major app store\(^\text{14}\). A majority of them (62%) allow users to access dermatology reference materials, databases, textbooks, and journals. Other apps can be grouped into three categories: apps that offer dermatology-based questions; apps intended for assisting in diagnoses; and apps with other miscellaneous uses, such as tutorials on how to perform biopsies\(^\text{14}\). However, what is absent is the integration of these apps in a telehealth setting, although it is important to note that mobile apps are gaining popularity as components in telehealth settings\(^\text{15}\). In our particular case, these kinds of mobile apps would not adequately address the identified challenges mentioned above. They did not provide picture-sharing
capabilities, and a storage repository is needed to make telehealth visits more efficient, improving teledermatology with face-to-face interaction, and medical education.

**Materials and Methods**

**Dermatology Image Database**

A novel, web-based dermatology image management application, Missouri Dermatology Image Database (MDID), has been developed to facilitate the practices in the Department of Dermatology at MU. The digital images captured at clinics are transferred to MDID’s secure server via an encrypted connection and sufficient user authentication. Uploaded images are organized by multiple criteria, including basic patient demographics (medical record number, name, gender, date of birth), clinic visit number and date, free text annotation, etc. DermLex\textsuperscript{TM}\textsuperscript{16} is used to annotate images with standardized diagnoses, as well as body locations where images are taken. Patients and images can be easily searched by previously introduced criteria. Therefore, MDID provides the dermatologists an instant tool to organize and search images. For example, MDID allows 1) finding all past images of a specific patient; 2) finding images with the same diagnosis, e.g. “acne”; and 3) finding images of patients who were seen at a specific clinic within a period of time. Images in MDID can also be organized based on users’ preferences into customized online folders. With MDID alongside the dermatologist, images are archived systematically and securely, and can be retrieved efficiently for use by daily practices in clinics, research, and education. Currently, there are 2,973 images in MDID from 878 patients. Extending the MDID to meet the needs of telehealth settings, we have developed the TeleMDID mobile application. In this paper, we outline a number of differences in the requirements and considerations for telehealth compared to the traditional clinical setting, and
make recommendations for the community to integrate mobile applications for teledermatology.

**Considerations of a Telehealth Setting**

Prior to the design of the mobile application, we conducted an informal observation of the telehealth workflow. A typical MTN telehealth dermatology session lasts between 15-25 minutes, and follows a procedure similar to a clinic visit, as shown on the left panel of Figure 3. The following discussion of Figure 3 will use lettered annotations to refer to the various components as marked. Due to the educational setting, a patient will typically visit with a resident prior to seeing a dermatologist. The visit is conducted over a Polycom system with high-resolution video displayed on a television screen. Images from the far-site clinic are transmitted through the Polycom system by attaching a digital camera on a secondary input through a hybrid store-and-forward solution. The patient photos are normally taken prior to establishing the telehealth session to save time during the actual visit (A).

There are a number of limitations to using the digital camera on a secondary input. First, the dermatologist has minimal control over the images being displayed. There is significant overhead associated with switching to secondary input, and the clinician must ask the far site to step through the images manually (B). This also interrupts communication with the patient, since the dermatologist no longer receives the video feed on the monitor. Additionally, the images must be presented twice for the resident and dermatologist (C). The staff at the far clinic must also be careful to remember to delete the photos from the digital camera after each session to maintain the confidentiality of each patient (D). Most significantly, once these images
are deleted, they are no longer available to the dermatologist for historical, diagnostic, or training purposes, as well as meta-data analyses.

Scheduling and availability are also significant considerations in a telehealth setting. Missed or late appointments can mean delays at both near and far clinics, as well as affecting other remote clinics. Even ensuring the right patient at the right location at the right time is complicated in a telehealth setting, as there are frequently multiple scheduling/registration systems and numerous opportunities for miscommunication. Based on these considerations, we have identified a number of ways for adapting mobile technologies from a clinical setting to telehealth. The first is the functionality to provide offline and interactive viewing of patient photos by the dermatologists. The second is the improvement of scheduling and appointment.
Finally, the photos and accompanying meta-data must be transmitted securely to an image repository during the appointment without leaving any copy on the local device.

**System Architecture**

The TeleMDID application is depicted on the right panel of Figure 3. There are three phases for the workflow as listed in the system architecture, namely *Preparation*, *Appointment*, and *Data Utilization*. In this section, we will provide a side-by-side comparison for all phases with the old workflow. Careful consideration was given to session establishment, management, and teardown for the TeleMDID application.

During the *Preparation* phase, the TeleMDID session enables far-site clinics to take photos of the patient prior to connection with the near clinic and make these images available to the dermatologist for assessment prior to establishing the telehealth session (E). This expedites the image review process, and allows the dermatologist to spend the session communicating directly with the patient. It must also handle the synchronization of image upload/download. We used a modified handshake process, with MDID in the middle to provide session management, to allow near and far-site clinics to act independently and connect reliably. Authentication is an important component of the application for ensuring proper session establishment between near and far clinics, and confirming the correct patient is available at the correct clinic. Each clinic has a unique username/password combination that identifies the location. Near clinic specialists authenticate with their university credentials to facilitate proper organization of the images within the MDID repository. All communication is encrypted via secure socket layer (SSL), and each request contains cross-site reference forgery (CSRF) protection measures to prevent session hijacking and spoofed clinic requests.
To facilitate MDID in cataloging patient visits, TeleMDID allows the clinician to enter a patient medical record number (MRN). Additionally, to save time in establishing the session, the barcode containing the MRN can be scanned directly from the chart, if available. When each clinic connects, they provide a device token, which is used by MDID to send push notifications (discussed below). The clinic is pushed onto a queue, and the second clinic can be notified of the waiting status. The near clinic is prompted with a list of the telehealth clinics and chooses the location with which to connect. The near clinic also enters the patient identifier used in the MDID system. In this way, the near clinic is wholly responsible for the patient and clinic used in the session. As a verification measure, the far-site clinic enters the patient name. While establishing the session, this allows each iPad to display the status of the remote location. In the improved workflow, the dermatologist is notified when the far-site clinic has logged into the application, when they are taking photographs, and whether the clinic is waiting for a session to be established.

During the Appointment phase, real-time operation is essential to the ease-of-use of mobile technologies in a clinical setting. To achieve real-time session management and image transmission, TeleMDID uses the Apple Push Notification Service (APNS), similar to the Android Cloud to Device Messaging (C2DM) for Android, for best-effort delivery of real-time information to the application. Push notifications deliver data to the application, even if they are in the background, to update the state of TeleMDID.

Once a session has been established, push notifications are used to inform the near clinic of new images and automatically retrieve them for display. Finally, notifications are used within TeleMDID to implement the “sharing” features, where the dermatologist may push an
image or handout to the remote screen for discussion with a patient (F). By viewing an image in full screen mode and pressing the “Share” button, the user can send the far site clinic device a notification, causing it to go into full screen mode and display the image, effectively mirroring the display. Because the traditional handouts used in the clinic are not available to far-site clinics, TeleMDID contains a database of documents that can be updated and shared with the far-site clinic. This allows the patient to receive information comparable to what he/she might receive during a non-telehealth visit, for printing, emailing, or taking notes, without the potential for communication error. Any patient photos taken over the course of a session are stored in main memory and never written to a file on the device. The images only exist for the duration of the session at the far site, but are housed in the MDID image repository for future retrieval. In this way, the images are only accessible to a specific clinic for a specific patient to reduce the risk of breach of confidentiality. Figure 4 shows a screenshot of the apps.

Figure 4: Image capturing and sharing function of the apps.
All communications from TeleMDID rely on the available wireless connection at the clinic. This frees the staff member to move the camera as necessary, and display the images to the patient on the tablet screen in a natural way. Additionally, the mobility of the tablet allows near clinic residents to take the iPad out of the room to discuss the images with the dermatologist (G). Figure 5 shows the dermatologist discussing the diagnoses with the patient located at one of the ten pilot sites. This greatly simplifies the communication between resident and dermatologist, and eliminates the need for multiple reviews of the photos on a secondary input.

Figure 5: Diagnosis process from a near-site provider using the mobile apps. (right) The mobile app was deployed in both near and far sites in Missouri, USA.

The integration with the MDID system creates a new phase in the workflow that occurs after the appointment. During the Data Utilization phase, images that are taken during a session and stored in the MDID repository can be used for case studies and discussions, to
conduct research on dermatology imagery, or even to be displayed during a subsequent appointment to show improvement or worsening of the patient’s symptoms (H).

**Survey and Assessment Methods**

The iPad apps were deployed to 10 far sites, as well as MU dermatology clinics. Two pre-launch and two post-launch internet-based surveys were distributed to far-site patient presenters and dermatology clinic providers in April 2013. Provider surveys were anonymous, while patient presenters were asked to specify clinic name and location for the purposes of identifying clinics that wanted to replace their digital dermatology cameras with iPads and TeleMDID apps. This research protocol has been approved by the University of Missouri Institutional Review Board (IRB) #1207257.

Pre-launch surveys examined the current experience with telemedicine, experience with portable medical devices, as well as any challenges with telemedicine technologies in current teledermatology clinics. The post-surveys examined the experience with TeleMDID, changes in teledermatology clinic workflow, and also asked for user recommendations. The surveys were emailed to participants, including presenters and coordinators from far sites and dermatologists from MU, prior to installation and deployment of iPads containing TeleMDID apps. Non-respondents were sent one reminder about five days after the initial recruitment email was sent. Post launch surveys were sent after the use of the app, with a reminder email sent to non-respondents five days later. The duration between pre- and post-survey for this study is 45 days, to obtain initial assessments that are timely and providing preliminary findings for this ongoing research.
Results and Discussion

The pre-launch survey of the teledermatology near-site providers showed that all of them (100%) have used both Polycom and digital cameras. However, their experience with teledermatology (Table 2) differs from the experience of far-site patient presenters. When it comes to assessing the providers and telehealth presenters’ expertise with telehealth on a scale of 0 (beginner) to 100 (advanced), the mean was 53.56. All providers, as well as far-site presenters (100%), stated they would be willing to use an iPad in conjunction with main telehealth equipment.

When it comes to challenges with the traditional teledermatology clinic, 77.8% of providers reported experiencing problems establishing the telehealth session, while 100% of providers reported telehealth scheduling errors resulting in delayed, missed, or incorrect appointments, etc. A high percentage of providers also reported relying on still images, with a mean of 87 on the scale of 0 (never) to 100 (always). Providers report occasionally having difficulties viewing still images (mean 55.33), and receiving poor quality images (mean 55.89).

All of the far-site rural clinics (100%) that participated in the survey reported using a Polycom telehealth system, and of those, 61.1% used digital dermatology cameras, and 16.7% used other telehealth technologies, such as digital stethoscopes, otoscopes, or document camera.

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Table 2: Experience with teledermatology for telehealth providers and patient presenters.
Although 77% of the far-site clinics reported they have a protocol to delete patient images from digital dermatology cameras, of those, 33% reported that images might be kept in the camera after the teledermatology sessions. This may cause patient privacy and confidentiality concerns, since photos left in the camera can be shown during other patient appointments. Also, there was no mechanism for storing these images for future clinical or educational use. Telehealth clinics did not link to the MDID database used for face-to-face patients, so the patient photos were lost once the photos were deleted from cameras.

Providers’ post-launch survey showed that 100% of the providers who used TeleMDID during our pilot study prefer using TeleMDID to the digital dermatology camera, while 75% of the far-site telehealth presenters preferred using TeleMDID. The mean for the ease of use was 74.25. Providers reported not experiencing change in establishing the connection using the TeleMDID, with the mean of 49.25. Far-site patient presenters reported that TeleMDID was somewhat easy to use, with the mean of 52. When asked if they had difficulty connecting via TeleMDID, 66.7% of the far clinics reported not having any difficulties, while 33.3% had difficulties, mainly due to sporadic wireless connections from their clinics. The results indicate that proper training and printed instructions for quick reference are needed to have successful deployments for the far sites.

Our aim was to adapt the in-person clinical technologies to the teledermatology clinic to compare its usability and effectiveness with current teledermatology modalities. Table 2 lists the experience with teledermatology for the provider and patient presenters of the far-site clinics. The subjects in our study have an adequate range of experience covering from new to seasoned practitioners.
Providers reported greater satisfaction with the TeleMDID app than far site clinic presenters, and they also viewed it as an improvement to the clinic flow. All of the providers had previously been using mobile technologies, iPhone, iPad, or Android, daily, compared to 30% far site rural clinics, which may have influenced their satisfaction level.

We have observed changes to all three phases of the workflow. During the Preparation phase, TeleMDID allowed for images to be transmitted to the provider-side prior to the appointment and connection through the Polycom system. This allowed providers to ensure that the patient was ready for the visit before dialing the far site. It also allowed them to view and prepare the images prior to interviewing the patient. This step ensured the connection to the appropriate far site and minimized the errors in dialing the incorrect location. This workflow improvement is shown in Module E of Figure 3.

During the Appointment phase, TeleMDID allowed for providers, patients, and telehealth presenters to view the images at the same time, increasing the awareness and education opportunities. Providers were able to switch between photos, and zoom in and out as needed, which allowed for a more efficient and uninterrupted visit. Providers reported an increase in efficiency of the appointment, with the mean of 65.50. Due to limited accessibility to technical support and expected learning curve, the far-site clinics reported that the efficiency of appointments has decreased, with the mean of 44.

Before installation of TeleMDID, all of the photos taken during teledermatology appointments were deleted after each visit. This resulted in inability to compare patient photos during follow up visits, use them as a teaching tool for students, residents and fellows, or conduct research and present case studies. The Data Utilization Phase has allowed for images
to be stored, which had a major impact on the way data are used in the teledermatology clinic. For a highly visual specialty, such as dermatology, this allows providers to quickly access photos from previous visits, as they do for their face-to-face patients, when needed.

**Conclusion and Future Work**

In this study, we have observed that the appointments with TeleMDID were more efficient, since the photos taken by the iPad app were ready prior to the connection via Polycom. This resulted in a shorter visit time for the patients in the clinic, and providers were able to spend more time on diagnosis without waiting for the far-site telehealth presenters to show photos on the screen and switch between inputs. While this study did not examine cost improvements, it is our empirical observation that the TeleMDID app has increased user and patient satisfactions by allowing for more streamlined and better organized appointments that are as close to in-person appointments as it is possible with telehealth.

Our future work has both implementation and research goals. For implementation, it is desirable to develop new functionalities for the mobile apps, and launch of a full-scale deployment of TeleMDID to 150 sites currently on the MTN network. Future improvements to this application include an interface for dermatologists to provide detailed meta-data about the images and annotate regions of an image, including the ability to view these highlighted regions on the far-clinic device in real-time. Additionally, patient history and diagnosis information will be available to the clinician to give a more complete picture of the patient. For far sites, improved training and technical support are needed. Further research is required to include potential cost savings specific to this solution, which includes the commonly used off the shelf technology, instead of costly cameras designed for one purpose. The use of TeleMDID app
showed clear improvement in teledermatology work flow, which is valuable information gained from this pilot study that could be verified in a large, more inclusive, rollout of the technology.
References


16 DermLexTM (http://www.aad.org/DermLex/)
CHAPTER 4: ROBOTIC TELEPRESENCE IN A MICU: CLINICIANS’ PERSPECTIVE

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Abstract

PURPOSE: To study the use of an intensive care unit (ICU) robotic telepresence in an academic hospital. To examine provider attitudes towards the usability and effectiveness of the ICU Robot.

INTRODUCTION: While the use of robotic telepresence is not a novel thing for outsourcing services, using it within the same academic department is not yet widespread. ICU Robots can be used to increase access to supervising physicians as well as other specialists, when not physically present in the hospital, reducing possible wait time for difficult admissions and procedures.

MATERIALS AND METHODS: The study was done as a post-interventional cross-sectional 7 question survey in a medical ICU (MICU) in an urban academic hospital. Subjects were attending physicians, fellows, residents, nurses, and respiratory therapists (RTs).

RESULTS: Users of the ICU Robot reported greater satisfaction with communication, and improved patient care, than non-users. Non-users’ perception of the ICU Robot indicated lack of trust in this modality, and a greater level of disengagement. Providers who have used the ICU Robot were less likely to have neutral opinion than non-users.
Non-users were, in general, less likely to have favorable opinion about the use of the ICU Robot.

CONCLUSIONS: Findings show the importance of a whole-team approach to the installation and implementation of an ICU Robot. The ICU Robot is an effective tool when used to visualize and communicate with patients, bedside staff, and families. However, providers not trained or shown how to use the ICU Robot appear to be disengaged or tend to have negative views of remote monitoring.

Introduction

Early experiments with telemedicine technologies in intensive care unit (ICU) settings found that the audiovisual technologies were adequate, but too expensive, for consultations in patient care\(^1\). Since then, ICU telemedicine has continued to grow and evolve, with the first formalized program developing in 2000\(^2,3,4\). Today, there are numerous ICU telemedicine programs across the country, utilizing different technologies (fixed, portable, or mHealth), employing different care models (continuous, pre-emptive/scheduled, or reactive) in a centralized or de-centralized tele-ICU\(^3\). PubMed search of robotics and telepresence and intensive and care and units yielded five journal articles\(^5,6,7,8,9\). One of the main observations of the differences between traditional videoconferencing systems in healthcare and robotic telepresence is that users tend to “interact with the robots as if it is a person”\(^5\). Even though the growth of ICU telemedicine seems to be remarkable, many barriers to implementation and adoption
remain - from medical liability, reimbursement, high costs, and provider resistance, to widespread disagreement about appropriate application\textsuperscript{6,10,11}.

Robotic telepresence in the ICU is used primarily to provide ICU physician coverage to rural and remote hospitals impacted by the shortage of specialists. There were 25 ICUs in North America using robotic telepresence, with a total of 56 robot endpoints in 2010, with almost 50\% of them being in academic institutions\textsuperscript{12}. Raynolds et al showed great provider satisfaction in this model, with 100\% of respondents reporting both patient care and patient satisfaction were improved by using the robot\textsuperscript{12}. At the University of Missouri Hospital, the ICU Robot is used in a very different way, however, to enable attending physicians to connect to the ICU for patient rounds, resident and fellow supervision, and respiratory therapists consults, when not physically present in the ICU. The aim of this pilot study was to assess user and non-user attitudes and perceptions of usefulness and effectiveness of the ICU Robot. The study was conducted to find out if these attitudes may have influence on actual usage of the ICU Robot.

Materials and Methods

Design, Setting, and Sample

The study was a post-interventional cross-sectional survey. It was conducted at a medical ICU (MICU) of an academic hospital, the University of Missouri Hospital and Clinics (UMHC). The MICU is an 18-bed closed intensive care unit, which represents one
of four types of intensive care units at UMHC, but it is the only one currently utilizing the ICU Robot.

The UMHC MICU is divided into two pods, staffed by the Division of Pulmonary, Critical Care, and Environmental Medicine. The healthcare team consists of physicians (attending, fellows, and residents), medical students, nurses, respiratory therapists (RTs), pharmacists, dieticians, and support staff (speech pathologists, physical and occupational therapists, unit clerks, housekeeping, etc.). The ICU Robot is used by pulmonary faculty to provide patient care and consultations with colleagues, fellows, residents, nurses, and RTs when the faculty members are not physically present in MICU. The remote physicians accessed the iPad app to connect to the Robot from different locations – home, administrative office, clinic, or even the ICU floor. Engaging the Robot was physician-driven: the physicians would connect to the Robot to check on the patient status based on the previous knowledge about a critically ill patient either being admitted to or currently treated in MICU. During the connection via the Robot, the physicians usually speak with the nursing staff and sometimes RTs. They would also communicate with residents and fellows if they were present at the time as well. The study respondents were 29 physicians (attending, residents, and fellows), nurses, and RTs. The study was approved by the University of Missouri Health Sciences Institutional Review Board.
**Survey Instrument and Survey Administration**

An evaluation was conducted to determine if MICU providers currently use the ICU Robot, their satisfaction with it, and if they find it useful and effective. During the study design process, literature and websites were utilized to identify best practices for survey design and deployment. The survey tool included seven specific questions that addressed the providers’ job title, use, and satisfaction with the ICU Robot. Items in Table 4 represent 5 of the 7 questions from the survey. The other two questions asked participants if they had used the Robot, and to leave comments if they had any.

Data were collected from October to December 2013 through an online survey via Research Electronic Data Capture (REDCap). REDCap is a secure web application for creating and managing online surveys and databases. REDCap provides audit trails for tracking data manipulation and user activity, as well as automated export procedures for seamless data downloads to Excel, PDF, and SPSS Statistics\(^2\). Participants received one initial invitation and up to three reminders to complete the survey, each at about two week intervals after the initial email was sent.

**Data Analysis**

Quantitative analysis was applied to examine the providers’ use of and attitude towards the ICU Robot using SPSS Statistical software. Scores for providers who have used the ICU Robot were compared with scores for providers who have not used the ICU Robot by computing a Mann-Whitney \(U\) statistic for ordinal data. Average scores,
standard deviations, ranges, and differences for each of the items, along with the respective levels of significance, were calculated.

Results

A total of 29 physicians, nurses, and respiratory therapists responded to the survey, accounting for a response rate of 48 percent (Table 3). The ICU Robot was used for a total of 72 minutes from October 26 to December 20, 2013, and only on Monday through Thursday, but not on Fridays or weekends. There was a total of 8 sessions, with an average of 9 minutes per session. All sessions were performed at different times of the day, between 10:00 am and 5:30 pm. A total of 5 (17%) of the respondents replied having used the ICU Robot. Of those, 3 (60%) were attending physicians and 2 (40%) were respiratory therapists. Nurses and fellows who responded to the survey all reported never having used the Robot. Four respondents who indicated never having used the ICU Robot did not complete the reminder of the survey.

There were significant differences between users and non-users of the ICU Robot [Table 3]. All of the ICU Robot users (100%) felt more confident caring for the patient, with the supervising physician observing the visit via the ICU Robot, vs. only 10% of the non-users. The remainder of non-users (90%) reported neutral opinions. Likewise, there were significant differences in opinions of providers that have used the Robot, reporting it improved the quality of care, compared to those who have not, who were more likely to have neutral opinions. However, there was little difference in opinions regarding having to wait for a physician to be physically present in the ICU. Although
there was no significant difference between users and non-users on waiting for the supervising physician to be present in order to perform the procedure or dispense medication, 25% of the users felt they could do it quicker by connecting via the ICU Robot, vs. 5.2% of the non-users.

<table>
<thead>
<tr>
<th>Clinical specialty</th>
<th>Invited</th>
<th>Participated</th>
<th>% Participation</th>
</tr>
</thead>
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<tr>
<td>Attending physicians</td>
<td>10</td>
<td>6</td>
<td>60%</td>
</tr>
<tr>
<td>Residents/Fellows</td>
<td>9</td>
<td>2</td>
<td>22%</td>
</tr>
<tr>
<td>Nurses</td>
<td>12</td>
<td>6</td>
<td>50%</td>
</tr>
<tr>
<td>RTs</td>
<td>30</td>
<td>15</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>61</strong></td>
<td><strong>29</strong></td>
<td><strong>48%</strong></td>
</tr>
</tbody>
</table>

Table 3: Survey respondents

Discussion

Users and non-users of the ICU Robot had very different opinions and attitudes towards usability and effectiveness. The five providers who have used the ICU Robot reported greater satisfaction, confidence in improved patient care, and ease of use, than those that have not used it. These self-identified users likely represent the actual users, and to the best of our knowledge, these five providers are the only ones who have utilized the Robot. Results indicate non-users tend to report greater disbelief in the use of the ICU Robot.

The low user number may be attributed to the lack of buy in and support from bedside staff, which is seen if there is no clear plan or purpose on how the remote monitoring will be done in an ICU. In this case, there was a half-day training provided for nursing staff and physicians, which they attended based on their individual availability. The training was hands-on and attendees used an iPad app to engage the
Robot. Clear plan and protocol on why and how the remote monitoring would be used may need to be integrated in the hands-on training to maximize the utilization. Lily and Thomas also observed the integration and acceptance of remote monitoring in ICU is greater when there are established standards and collaborative rounding models and agreements among providers. The providers who used the Robot were self-selected; those who indicated during the hands-on training that they wanted to have an iPad app to control the Robot are the ones that continued to use it.

Robotic telepresence in the UMHC MICU does not seem to be used to its full potential. A very small number of physicians are currently using the Robot, and even they use it minimally. One of the challenges to telemedicine in any setting is getting a buy-in from the providers and clerical staff. However, those who have used it most often perceive it as a useful tool that increases efficiency and patient care. Providers who used the ICU Robot show high confidence in caring for patients with attending physicians observing via the Robot. Somewhat unsurprisingly, providers who have not used the Robot have opposite views and report less confidence for caring for patients with attending providers observing the visit from remote location. In general, there seems to be a dichotomy in provider attitudes, which may be related to lack of preparation and training. In other words, the difference in attitudes towards the ICU Robot is based upon the inclusion of potential users in the implementation of the Robot, which ultimately affects the usage. The low usage by current users may also be attributed to the exclusion of the Robot from the everyday MICU practice.
Preparation of ICU Robot protocols and training that includes all bedside staff and essential clerical personnel might promote more acceptance and use. We also suggest identifying a provider champion on all care and administrative levels that would assist with staff buy-in to maximize the usage of the Robot.

<table>
<thead>
<tr>
<th>Item</th>
<th>Providers who have used the ICU Robot</th>
<th>Providers who have not used the ICU Robot</th>
<th>Difference</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>It was easy to use the ICU Robot.</td>
<td>1.6 ± 0.9 (1 - 3)</td>
<td>3.0 ± 0.2 (2 - 3)</td>
<td>1.4</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>The ICU Robot enhanced the visit with the patient by allowing visual contact.</td>
<td>1.8 ± 1.1 (1 - 3)</td>
<td>3.0 ± 0.3 (2 - 3)</td>
<td>1.2</td>
<td>0.003</td>
</tr>
<tr>
<td>I felt more confident caring for the patient with the supervising physician observing through the ICU Robot.</td>
<td>1.6 ± 0.5 (1 - 2)</td>
<td>3.0 ± 0.5 (2 - 4)</td>
<td>1.4</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>With the use of the ICU Robot, I do not have to wait for the physician to be physically present in the ICU to perform a procedure or dispense medication.</td>
<td>2.8 ± 1.3 (1 - 4)</td>
<td>3.1 ± 0.5 (2 - 5)</td>
<td>0.3</td>
<td>0.902</td>
</tr>
<tr>
<td>The ICU Robot improves the quality of our care.</td>
<td>1.8 ± 0.8 (1 - 3)</td>
<td>3.1 ± 0.4 (2 - 4)</td>
<td>1.3</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Table 4: Provider attitudes towards the ICU Robot

Our study had several limitations. Having a small number of users of the ICU Robot may not have given us an accurate picture of the differences between users and non-users. We conducted the study in the MICU of an academic medical center. Our results may not be applicable to other ICU units, different clinical departments, or non-academic medical centers.
Future studies should include the ways in which having the inclusion suggestions made above could impact implementation, acceptance, usage, and provider satisfaction with an ICU Robot. The studies also could include other departments that may be using the Robot internally and compare the results.
References


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CHAPTER 5: THE OVERVIEW OF CHILD AND ADOLESCENT TELE-PSYCHIATRY SERVICES – UNIVERSITY OF MISSOURI, COLUMBIA

Abstract

Objective: This study compared University of Missouri child and adolescent telepsychiatry services patients’ specific zip-codes to child and adolescent psychiatrists’ locations to learn if telehealth was an appropriate option for this group of patients.

Methods: Management analyst system Cognos/Analyzer was used as a data source. Patient and provider specific zip-codes were processed using GeoKettle software and ArcGIS explorer was used for map visualization.

Results: While patients utilizing child and adolescent telepsychiatry services come from various parts of the state, providers are mostly clustered in urban locations along Interstate 70. This greatly limits access to specialty care for rural and other vulnerable populations. Telehealth provides adequate and timely access to child and adolescent psychiatry services for youth that may otherwise not be able to get needed care.

Conclusion: Mental health crisis and access to care barriers for rural population have been more or less successfully addressed by telehealth for several decades now. However, the shortage of specialty physicians adds an additional layer of complexity to this issue. Health care organizations with informatics tools, such as telemedicine, need to focus their efforts on maximizing usage to allow more access for underserved population.
Introduction

The state of Missouri is a largely rural state: only 14 counties are considered urban, while 101 counties fall under the rural category\(^1\). Almost 40 percent of the population lives in these rural areas, which cover about 90 percent of the total Missouri land\(^1,2\). For this study, we have adopted the urban/rural definition based on population density: urban counties are those with a population density of over 150 people per square mile. In addition, counties that are at least partially covered by a Metropolitan Statistical Area (MSA), as defined by the US Census Bureau, are also considered urban\(^1\).

One of the biggest healthcare crises the state is facing is the physician shortage in rural areas. Only 18 percent of primary care providers currently practice in rural Missouri\(^1\). Missouri was also “below the national average of 8.67 child and adolescent psychiatrists per 100,000 youth in 2001,” with only 7.1 child and adolescent psychiatrists per indicated population\(^3\). Reports indicate that between 7 and 20 percent of youths are affected by mental health disorders\(^4,5\), and for those living in rural and underserved areas, evidence-based and state-of-the-art child and adolescent psychiatric treatment may not be available\(^4,6\). Fast forward to 2013, Dell (2012) gives a grave overview of the severity of the continuation of the shortage\(^7\). The Council on Graduate Medical Education (COGME) predicted, in 1990, that, in 2000, there would need to be 30,000 child and adolescent psychiatrist practicing in the United States, based on the estimated needs for treatment; instead, there were only 7,000\(^7,8\). This crisis, unfortunately, does not only affect youth in rural areas, but all impoverished populations, rural or urban, quite significantly\(^7,8\).
Telehealth services help bridge this gap between urban and underserved health care, and offer patients access to services no matter where they choose to live. Through telehealth, child and adolescent psychiatry reaches youth that need these services, and offers valuable assistance. The University of Missouri Department of Psychiatry (MUPC) Child and Adolescent Division has operated since 1967. They started their telehealth program in 2002. The services are provided to community mental health centers and the Missouri Division of Youth Services (DYS). We conducted our study to learn the locations of youth utilizing child and adolescent psychiatry services from the University of Missouri (MU). We also wanted to learn where the nearest in-person child and adolescent psychiatrists in the state are, relative to patient locations, to understand better if telepsychiatry services were not available, would they likely have appropriate and adequate care.

Methods
The study was approved by the MU Institutional Review Board (IRB). Data were collected from the management analyst system Cognos/Analyzer from July 1, 2013 – May 31, 2014. Patient-specific zip codes were processed using the GeoKettle software, and the ArcGIS Explorer was used to visualize the data on a map. In addition, in-person child and adolescent psychiatrists’ specific zip codes were processed and mapped using the same software. We used GeoKattle software to calculate the distance between each patient and the nearest in-person child and adolescent psychiatrist.
Both hub and spoke sites use Polycom videoconferencing systems, high-speed internet – the mix includes T1 lines, fiber, and Ethernet. The hub site, also called the distant site or far site, is the site where the provider goes to see the patient via telehealth. The spoke site, or the originating or near site, is the site where the patient goes to be seen by the provider via telehealth. The minimum requirement for the video conference is 1.5 mbps. The minimum speed of each video-call is 384 kbps.

Results

There were 662 appointments for 179 patients with 19 different zip-codes that took place during the study period. The patients were from 13 to 20 years old. The average age of the patient was 15.9 years old. Over 90% of the patients were Missouri Medicaid patients, with the remainder being covered by private insurers.

The patients utilizing child and adolescent telepsychiatry services from MUPC were from various parts of the state (Figure 6), and do not seem to be clustered in particular regions. Not surprisingly, though, the majority of the providers (in-person and telehealth) are located in urban areas along the I-70 corridor in Missouri – Kansas City (13 providers), Columbia (24 providers), and St. Louis (42 providers). There are another 42 providers spread out in other parts of the state, more specifically southwest, southeast, and northeast (Figure 6).
We examined the distance between patients and in-person child and adolescent psychiatrists. If telehealth is taken out of the equation, the range of distance between patients and providers is 1.14 mi to 301.6 mi. The average distance a patient is from the closest provider is 22.2 miles. The patient farthest from the provider lives 301.6 miles away.

**Discussion**

The results of the study indicate that the majority of child and adolescent psychiatrists in Missouri provide services in or around four major cosmopolitan areas – St. Louis, Columbia, Kansas City, and Springfield. Although there are child and adolescent psychiatrists in other areas of the state, many rural counties are left without
access to adequate mental health care for youths. All of the child and adolescent psychiatrists are located in mental health professional shortage areas (HPSAs), as designated by the US Department of Health and Human Services, Health Resources and Services Administration\textsuperscript{10}. For patients from those areas, telepsychiatry seems to be an appropriate solution for access to psychiatric services.

Our findings are consistent with Lal and Adair\textsuperscript{11}, who indicate that telehealth and e-health are recognized as especially beneficial for vulnerable populations, such as rural and underserved populations. In addition to closing the gap for access to care, telehealth helps overcome other major mental health hurdles, such as stigma\textsuperscript{12, 11}. Telehealth offers a certain level of anonymity for mental health services, as children and adolescents go to primary care offices to be seen by specialists via video. In addition, telehealth services, in this study, are provided to children in DYS custody. In order to see their provider via video, they just need to walk down the hall in their facility. However, to see their provider in person, they are taken in handcuffs and shackles out of the DYS facility. There were a total of 179 patients seen during our study time; and for many of them, telehealth might have been the only option to see a qualified mental health provider in a timely fashion.

It is also important to recognize that the large majority of patients utilizing these services are Missouri Medicaid patients. Sixty percent of all Missouri Medicaid enrollees are 18 years or younger, which is also the largest demographic group of all Medicaid
participants\textsuperscript{13}. This equals to over half a million children that received their health insurance through Missouri Medicaid in 2010\textsuperscript{13}.

Our study was limited by the fact that the management analyst system that was used collected data from M UPC clinic scheduling, which does not contain information about all of the M UPC appointments. Some of the patients scheduled for telehealth appointments are scheduled through a separate system not available for electronic data analyses.

**Conclusion**

Although our study focused only on the child and adolescent psychiatry services provided by an academic hospital, we feel our findings are extremely valuable, in that they show the extent to which the specialist services are centralized in urban regions, while the more remote populations have severe barriers to access to care. While this is not a new discovery, it highlights the severity of the mental health service crisis, especially for child and adolescent psychiatry. There has been an increase in use of and demand for psychiatric services; however, there has not been an adequate increase in supply to meet the increased demand\textsuperscript{14}.

Future studies should include specific patient diagnoses by patient-specific locations. We also recommend analyzing the current trend of demand for and supply of child and adolescent psychiatrists in Missouri, as well as the extent of the use of telepsychiatry from all sources.
References


6 Chorpita, BF: Treatment manuals for the real world: where do we build them? Clinical Psychology Science and Practice 431-33, 2002


8 AACAP Workforce fact sheet. 2013. 4 August 2014


CHAPTER 6: CONCLUSION

In a current state of healthcare systems being burdened by lack of specialty providers, especially in rural areas, the questions of delivering quality and affordable healthcare in a timely fashion to patients becomes even more challenging\textsuperscript{61}. Medical schools across the country are already making efforts in changing and adapting their curriculums in order to prepare students not only for practice in urban areas, but also in rural and underserved.

This research examined the efficiency of telehealth technologies on provider adoption and usage, in order to predict the usability and effectiveness of three different modalities in three different specialties. First, I studied the adoption of mHealth in a clinic that has a long history of traditional telehealth usage. Second, I studied the adoption of the ICU Robot in an inpatient setting. Lastly, I examined the usage of the child and adolescent telepsychiatry services in rural Missouri and with the captive youth population.

Based on the data collected during pre- and post- mHealth study in the teledermatology clinic, we can conclude that mHealth can be successfully adopted in a traditional teledermatology clinic. mHealth can also replace the digital cameras used previously, which can improve the clinic flow and mimic in-person dermatology clinic to a higher degree. The number one reason for adoption of mHealth technologies by providers is time efficiency, followed by cost efficiency and improved quality of care\textsuperscript{62}. 
In teledermatology clinics, providers using mHealth TeleMDID app can access photos sooner, discuss them with their patients, and educate them on their conditions and appropriate use of medicine prescribed in a more streamlined fashion. All providers that have used the app have reported greater satisfaction with their telemedicine clinic than before the adoption of the app. In addition, the app was found to be more user friendly and easier to use.

Interestingly, the second study showed similarly high user satisfaction with their telehealth unit, in this case MICU robotic telepresence, but a certain level of mistrust in the usability and efficiency by non-users. The users reported that robots can be used internally as an effective tool to see patients and supervise residents; however, the usage is limited by the small number of trained providers. These findings can also be attributed to a certain level of saturation with innovation and different technologies, not just telehealth\textsuperscript{63}. The diffusion of innovation theory predicts the growth of innovative technologies will slow down and even plateau as the late adopters come on board\textsuperscript{63}. While this is not necessarily the case in this instance, it is a unique challenge that will have to be anticipated, as the adoption of telemedicine progresses. We conclude that ICU Robots are adequate tools that help with a more timely access to critical patients and supervision of resident. However, proper protocols need to be developed that address the specific usage as well as an overall departmental plan, which are shared among faculty and staff. Providers will feel disengaged and even left-out if
not included in new-technology usage decision making, which can result in high-quality, high-cost equipment being severely underutilized.

The third study in this dissertation wanted to answer the question of availability of in-person psychiatric services for a specific group of patients – children and adolescent. Our findings indicated that for the majority of patients using telepsychiatry services, this was the only option for timely and quality care. Psychiatry is one of the specialties that face a very serious shortage, and where the demand for services surpasses the supply. To make things even more complicated, child and adolescent psychiatry is a sub-specialty that requires additional training and even metropolitan and other urban areas are challenged with access to this type of care.

In summary, the main contribution of this research to the field of health and medical informatics is its evaluation of adoption and usability of technologies from the provider perspective, vs. the more traditional approach of examining patient satisfaction, or even provider satisfaction without fully understanding the implications of attitudes on the adoption itself. This study has focused purposefully on different groups of providers using different types of telehealth technologies. By doing so, my intention was to point to the richness and complexity of telehealth, and the fact that by choosing to study only one we would miss the much bigger picture of how it actually contributes to the health care organizational structure. The health information technology field has, for a long time, been concerned mostly with the very important, yet still limited, path of electronic medical records, computerized physician order entry,
and decision support systems. Telehealth has not enjoyed the same level of attention, and my research attempted to bring the awareness to the significance of studying and understanding the barriers and successes, so that organizations and providers can take its full advantage, as various technologies become more affordable and easier to use.
### APPENDIX A: PROVIDER AND PATIENT SATISFACTION WITH TELEHEALTH LITERATURE REVIEW

Table 5: Provider and Patient Satisfaction with Telehealth Literature Review

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<td>Garrett CCKirkman MChen MYCummings RFuller CHocking JTomnay JEFairley CK</td>
<td>Clients' views on a piloted telemedicine sexual health service for rural youth.</td>
<td>Sexual Health. 9(2):192-3, 2012 May.</td>
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<td>Journal ArticleMulticenter StudyRandomized Controlled TrialResearch Support, N.I.H., ExtramuralResearch Support, Non-U.S. Gov't</td>
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<td>Contemporary Clinical Trials. 29(3):376-95, 2008 May.</td>
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<td>Gagnon MPDuplantie JFortin JPLandry R</td>
<td>Exploring the effects of telehealth on medical human resources supply: a qualitative case study in remote regions.</td>
<td>BMC Health Services Research. 7:6, 2007.</td>
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<td>Mair FSGoldstein PMay CAngus RShiels CHibbert DO Connor JBoland ARoberts CHaycox ACapewell S</td>
<td>Patient and provider perspectives on home telecare: preliminary results from a randomized controlled trial.</td>
<td>Journal of Telemedicine &amp; Telecare. 11 Suppl 1:95-7, 2005.</td>
<td>Clinical TrialJournal ArticleRandomized Controlled TrialResearch Support, Non-U.S. Gov't</td>
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<td>Kjaer NK, Karlsen K</td>
<td>[Telemedicine and general practice--future or present. Telemedicine, a way to strengthen the gatekeeper role?]. [Review] [27 refs] [Danish]</td>
<td>Ugeskrift for Laeger. 164(45):5262-6, 2002 Nov 4.</td>
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### APPENDIX B: EVALUATION OF HOME HEALTH LITERATURE REVIEW

Table 6: Evaluation of Home Health Literature Review

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78
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Cilli M  
Renzetti E  
Majo F  
Soldi D  
Lucidi V  
Bella F  
Bella S | Remote telematic control in cystic fibrosis. | Clinica Terapeutica.  
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| Ovid MEDLINE(R) | Varnfield M  
Karunanithi MK  
Sarela A  
Garcia E  
Fairfull A  
Oldenburg BF  
Walters DL | Uptake of a technology-assisted home-care cardiac rehabilitation program. | Medical Journal of Australia.  
| Ovid MEDLINE(R) | Luptak M  
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<td>Rumberger, JS Dansky, K</td>
<td>Is there a business case for telehealth in home health agencies?</td>
<td>Telemed J E Health. 12(2):122-7</td>
<td>Journal Article</td>
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### APPENDIX C: ROBOTICS IN ICU LITERATURE REVIEW

**Table 7: Robotics in ICU Literature Review**

<table>
<thead>
<tr>
<th>DATA BASE</th>
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## APPENDIX D: EVALUATION OF MHEALTH AND EHEALTH LITERATURE REVIEW

Table 8: Evaluation of mHealth and eHealth Literature Review

<table>
<thead>
<tr>
<th>DATA BASE</th>
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<th>TITLE</th>
<th>SOURCE</th>
<th>PUBLICATION TYPE</th>
</tr>
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<tr>
<td>Ovid MEDLINE(R)</td>
<td>Burns MN&lt;br&gt;Montague E&lt;br&gt;Moehr DC</td>
<td>Initial design of culturally informed behavioral intervention technologies: developing an mHealth intervention for young sexual minority men with generalized anxiety disorder and major depression.</td>
<td>Journal of Medical Internet Research. 15(12):e271, 2013.</td>
<td>Journal Article&lt;br&gt;Research Support, N.I.H., Extramural</td>
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<tr>
<td>Ovid MEDLINE(R)</td>
<td>Leon N Schneider H Daviaud E</td>
<td>Applying a framework for assessing the health system challenges to scaling up mHealth in South Africa.</td>
<td>BMC Medical Informatics &amp; Decision Making. 12:123, 2012.</td>
<td>Journal Article Research Support, Non-U.S. Gov't</td>
</tr>
<tr>
<td>Ovid MEDLINE(R)</td>
<td>Jensen CD Aylward BS Steele RG</td>
<td>Predictors of attendance in a practical clinical trial of two pediatric weight management interventions.</td>
<td>Obesity. 20(11):2250-6, 2012 Nov.</td>
<td>Journal Article Randomized Controlled Trial Research Support, U.S. Gov't, P.H.S.</td>
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</table>
APPENDIX E: TELEMDID SURVEY TOOLS

Cover Letter/Consent

To:

Date:

My name is Mirna Becevic and I’m a PhD student at the University of Missouri, Columbia, Informatics Institute (MUII). I also work as an Assistant Director for the Missouri Telehealth Network.

The purpose of this letter is to invite you to participate in a research project I am working on for my degree. In addition to the research paper, I will also use the study results in my job to evaluate the current and future needs for telehealth dermatology in Missouri.

I am examining the ease of use and satisfaction with the telehealth dermatology services in Missouri. I am working with another PhD student at the MUII, Blake Anderson, who is developing an iPad app to be used for telehealth dermatology. After the initial pre-survey, we will install iPads with the new app to selected clinics and conduct a series of surveys at 1 week, 2 weeks, 1month, and 3 months to evaluate the ease of use and satisfaction with the new telehealth model. Your participation is very important, as mobile technologies in telehealth may have a significant impact on health care delivery at a distance.
This survey is anonymous. However, identifiers will be used to determine which clinics are interested in replacing current digital cameras with iPads. The online survey is conducted via secure REDcap web portal. All paper documents will be stored in a secure and locked cabinet.

Thank you!

Mirna Becevic, MHA

becevicm@health.missouri.edu

cell: 573-673-5314

office: 573-884-5737
Provider Pre-Survey

Confidential

Survey

Please complete the survey below.
Thank you!

Teledhealth experience

How long have you used telehealth technologies?
- Less than 1 year
- 1-2 years
- 3-5 years
- 8 or more

What type of teledhealth equipment have you used?
- Polycom camera
- Digital derm camera
- Other
  (check all that apply)

If Other, please specify

________________________

How do you rate your expertise with teledhealth equipment?
- Beginner
- Intermediate
- Advanced

(Place a mark on the scale above)

Experience with mobile technology

Have you used mobile technology?
- Seldom
- Often
- Daily

(Place a mark on the scale above)

Would you be willing to use an iPad in conjunction with the main teledhealth equipment?
- Yes
- No

Challenges with technology

Have you had any problems establishing the telehealth session?
- Yes
- No

Have you had problems communicating instructions to patients?
- Never
- Sometimes
- Always

(Place a mark on the scale above)

Have you ever had a telehealth schedule error with negative outcome (delayed appointment, missed appointment, wrong patient etc.)?
- Yes
- No

www.project-redcap.org
Image quality

How often do you rely on still images?

Never | Sometimes | Always

__________________________________________________________

(Place a mark on the scale above)

How often do you require additional images?

Never | Sometimes | Always

__________________________________________________________

(Place a mark on the scale above)

Have you had difficulties viewing still images?

Never | Sometimes | Always

__________________________________________________________

(Place a mark on the scale above)

How often do you receive poor quality still images?

Never | Sometimes | Always

__________________________________________________________

(Place a mark on the scale above)

Have you had any issues with image quality related to flash being on or off?

☐ Yes
☐ No

__________________________________________________________

Recommendations

Please provide suggestions for improving the flow of telehealth appointments.

__________________________________________________________

Are you able to see patients within the allocated time?

Rarely | Sometimes | Usually

__________________________________________________________

(Place a mark on the scale above)

Would you be comfortable with a store-and-forward telehealth clinic model (diagnosing via still images sent electronically without the need for live interactive video)?

☐ Yes
☐ No
Provider Post-Survey

Confidential

Survey

Please complete the survey below.

Thank you!

---

**Experience with TeleMDID**

1) How often have you used the TeleMDID app for tele-dermatology appointments?
   - □ Less than once a month
   - □ 1-3 times a month
   - □ 4-6 times a month
   - □ More than 6 times a month

2) Do you find it easy to use TeleMDID?
   - □ Not easy
   - □ Somewhat easy
   - □ Very easy

3) Do you prefer using TeleMDID to the digital dermatology camera?
   - □ Yes
   - □ No

---

**Changes to workflow**

4) Have you experienced a change in establishing the connection with the far clinic?
   
   - □ Worse
   - □ Same
   - □ Better

5) How has TeleMDID affected the efficiency of appointments?
   
   - □ Less efficient
   - □ Same
   - □ More efficient

6) How has TeleMDID affected communication during appointments (including written instructions)?
   
   - □ Worse
   - □ Same
   - □ Better

---

**Recommendations**

7) Please provide feedback for improving TeleMDID.

8) Would you be comfortable with a store-and-forward clinic model (diagnosing via still image sent electronically without the need for live interactive video)?
   - □ Yes
   - □ No
Patient Presenter Pre-Survey

Confidential

Survey

Please complete the survey below.
Thank you!

Clinic name and location

---

**Telehealth experience**

How long have you used telehealth technologies?  
- Less than 1 year
- 1-2 years
- 3-5 years
- 6 or more

What type of telehealth equipment have you used?  
- Polycom camera
- Digital dermatology camera
- Other
  (check all that apply)

If Other, please specify

---

How do you rate your expertise with telehealth equipment?  
Beginner  Intermediate  Advanced

---

**Experience with portable digital equipment**

Do you find it easy to use the digital dermatology camera?  
- Not easy
- Somewhat easy
- Very easy

---

Have you ever had difficulties connecting digital dermatology camera to Polycom camera?  
- Yes
- No

Have you used mobile technology?  
- Seldom
- Often
- Daily

---

Would you be willing to use an iPad in place of digital dermatology camera to take patient photos?  
- Yes
- No

Does your clinic have wireless internet capability?  
- Yes
- No

---

**Challenges with technology**

Have you ever forgotten to delete images from digital dermatology camera after an appointment?  
- Yes
- No

Have you had any problems establishing the telehealth session?  
- Yes
- No

Have you ever found it difficult to use the digital dermatology camera to follow dermatologist’s instruction?  
- Yes
- No

---

www.project-redcap.org  REDCap
Have you had any difficulties providing patients with information (notes, prescriptions and flyers) as instructed by dermatologists?  

☐ Yes  
☐ No

**Recommendations**

Please provide suggestions for improving the flow of telehealth appointments.

How often do you offer telehealth option vs. in person to your patients who live far away from specialists?

<table>
<thead>
<tr>
<th>Never</th>
<th>Sometimes</th>
<th>Often</th>
</tr>
</thead>
</table>

(Place a mark on the scale above)

Would you be more likely to refer patients to telehealth if there was a store-and-forward option (diagnosing via still image sent electronically without the need for live interactive video)?

☐ Yes  
☐ No
Survey

Please complete the survey below.
Thank you!

1) Clinic name and location

Experience with tele-MOID

2) How often have you used the TeleMDID app for tele-dermatology appointments?
   - Less than once a month
   - 1-3 times a month
   - 4-6 times a month
   - More than 6 times a month

3) Do you find it easy to use TeleMDID?
   - Not easy
   - Somewhat easy
   - Very easy

4) Have you ever had difficulties connecting the iPad to the Polycom camera?
   - Yes
   - No

5) Do you prefer using TeleMDID to the digital dermat camera?
   - Yes
   - No

Changes to workflow

6) Have you experienced a change in establishing the connection with the tele-dermatologist?
   - Worse
   - Same
   - Better

7) How has TeleMDID affected the efficiency of appointments?
   - Less efficient
   - Same
   - More efficient

8) How has TeleMDID affected communication during appointments (including written instructions)?
   - Worse
   - Same
   - Better

Recommendations

9) Please provide feedback for improving TeleMDID.

10) Have you increased referrals to telehealth since installation of TeleMDID?
    - Yes
    - No

11) Would you be more likely to refer patients to telehealth if there was a store-and-forward option (diagnosing via still image sent electronically without the need for live interactive video)?
    - Yes
    - No
APPENDIX F: ROBOTICS IN ICU SURVEY TOOLS

Cover Letter/Consent
To:
Date:

My name is Mirna Becevic and I’m a PhD student at the University of Missouri, Columbia, Informatics Institute (MUII). I also work as an Assistant Director for the Missouri Telehealth Network.

The purpose of this letter is to invite you to participate in a research project I am working on for my degree. In addition to the research paper, I will also use the study results in my job to evaluate the current and future needs for use of robotics in critical care and ICU.

I am examining the ease of use and satisfaction with the InTouch Health Robots at MU Medical ICU and Lake Regional Hospital ICU. I am working with another PhD student at the MUII, Martina Clarke, on this project. Dr. Harjyot Sohal is our PI, and IRB number 1208335.

You will be asked to complete a survey that will take approximately 1 minute. Your participation is very important, as robotic technologies in hospitals may have a significant impact on health care delivery, quality improvement and cost savings.

This survey is anonymous. The online survey is conducted via secure REDcap web portal. All paper documents will be stored in a secure and locked cabinet.

Thank you!

Mirna Becevic, MHA
becevicm@health.missouri.edu
cell: 573-673-5314
office: 573-884-5737
Provider Survey

_____ Attending Physician

_____ Resident Physician

_____ Respiratory Therapist

_____ Nurse

1. I have used the ICU Robot.
   Yes   No

2. It was easy to use the ICU Robot.
   ☐ Strongly Agree   ☐ Agree   ☐ Neutral   ☐ Disagree   ☐ Strongly Disagree

3. The ICU Robot enhanced the visit with the patient by allowing visual contact.
   ☐ Strongly Agree   ☐ Agree   ☐ Neutral   ☐ Disagree   ☐ Strongly Disagree

4. I felt more confident caring for the patient with the supervising physician observing through the ICU Robot.
   ☐ Strongly Agree   ☐ Agree   ☐ Neutral   ☐ Disagree   ☐ Strongly Disagree

5. With the use of the ICU Robot, I do not have to wait for the physician to be physically present in ICU to perform a procedure or dispense medication.
   ☐ Strongly Agree   ☐ Agree   ☐ Neutral   ☐ Disagree   ☐ Strongly Disagree

6. ICU Robot improves our quality of care.
   ☐ Strongly Agree   ☐ Agree   ☐ Neutral   ☐ Disagree   ☐ Strongly Disagree

7. Please give examples to your answer in 6 above:
   ____________________________________________________________
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Telehealth. HRSA Health Resources and Services Administration. [Online] [Cited: August 26, 2014.] http://www.hrsa.gov/ruralhealth/about/telehealth/.


Insight into physician adoptions and challenges of mobile health

VITA

Mirna Becevic was born in Mostar, Bosnia and Herzegovina, in 1974. She graduated from Grammar School ‘Aleksa Santic’ in 1992 majoring in English and German. After several years of working with the European Union Administration of Mostar as an interpreter, she moved to Columbia, Missouri in 2001.

Ms. Becevic received a Bachelors of Arts in Sociology and Psychology from Columbia College in 2006. She received a Masters in Health Administration in 2010 from the University of Missouri.

Ms. Becevic has worked with the University of Missouri, Missouri Telehealth Network since 2007, first as a telehealth coordinator, and then later as an associate director. Her responsibilities include training and supervision of telehealth staff, as well as the development of new telehealth start-ups, business plans, and strategies.

Ms. Becevic’s research interests include technology in health care, rural health, access to care, and public health.