

# The Limitations of Video-Based Telemedicine Systems

Daniel Hawkins and Carman Neustaedter

School of Interactive Arts and Technology, Simon Fraser University  
250-13450 102<sup>nd</sup> Avenue, Surrey, BC, Canada  
drhawkin@sfu.ca, carman@sfu.ca

## ABSTRACT

We conducted an interview and observational study of current video-based telemedicine health consultations to understand how they are used by patients and health providers and what challenges, if any, exist. Our results reveal challenges relating to four main themes: privacy and awareness, body language, emotional expression, and playfulness and humor. Patients and providers experienced issues in each of these areas where pertinent content was not visible over the video link or patients did not know who all could see it. Overall, these findings illustrate the need to consider design suggestions from across the literature on workplace media spaces and domestic video usage, while also considering the unique context of health consultations.

## Keywords

Telemedicine, health, video communications, telepresence

## INTRODUCTION

There is a growing need in the health care community to provide technology to support telemedicine over distance where video conferencing systems are used to connect health professionals and patients in different locations. Such telemedicine setups have the potential to reduce the cost of health care services and provide health consultations to those who are unable to travel to locations containing health professionals [12]. The goal of our existing video conferencing-based telemedicine systems and how designs can be improved, if at all, to better support the needs and workflow of health professionals and patients. We studied the use of non-portable systems that are already in use in health facilities in Canada.

We conducted observations of four patient consultations with remote specialists and interviewed all four patients plus four health professionals. Our study goal was to understand health professionals' work practices and the challenges they experienced with video-based telemedicine systems, if any. Here we used a lens from past CSCW literature on media spaces and video conferencing.

Our research shows that the non-portable telemedicine systems that we studied provide basic support for remote consultations, yet they also expose many challenges. We use these to draw out design sensitivities to four salient

themes—privacy and awareness, body language, emotional expression, and playfulness and humor—that affect patient and health provider interactions and the use of video telemedicine systems. We explore these themes and reflect on the design of video-based telemedicine systems to present opportunities for future designs.

## RELATED WORK

### Telemedicine Systems and Studies

Telemedicine is defined as the use of technology to support medical assessment and analysis over distance [15,22]. It has been shown to be important for rural areas lacking medical professionals [22] as well as in cases where patients are unable to leave their home (e.g., cases of chronic illness) [15]. Many telemedicine systems focus on the sharing of electronic medical records and diagnostic information between healthcare professionals [15]. This information is often discussed using technologies such as the telephone and text messaging [15]. Studies of the satisfaction of patient and healthcare professionals show that both groups value asynchronous as well as synchronous telemedicine systems [25].

More recently, we have seen the incorporation of video conferencing solutions into telemedicine systems [10] where people are receptive to such technologies, if available, because they see the value in gaining increased access to health services [7]. Research has also shown that it is possible to develop training programs for video-based telemedicine systems and cost/benefit models show the economic benefits of such systems [10]. Kahn [13] proposed a series of challenges for telemedicine research. These include investigations of cost effectiveness, legal and regulatory infrastructures, and the unintended consequences of telemedicine. The latter refers to the effects of not seeing a doctor in person and potential issues related to doctor-patient relationships, privacy, and trust.

Together this research provides a basis for understanding the utility of telemedicine systems and user satisfaction with them. Yet it does not provide any investigations of how video conferencing-based telemedicine technologies should be designed to support existing doctor-patient workflows and in what ways varying design attributes may affect these workflows.

### Video-Mediated Communication

While not specifically focused on health consultations, there is a large body of research that explores the use of video-mediated communication systems in the workplace

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and domestic life. This sheds light on potential challenges with telemedicine systems and we use it as a lens for our investigations.

First, video communications research in the workplace has explored how video can be used to support both casual interactions between work colleagues as well as focused meetings [5,6,8,26]. In these setups, design concerns focused on where cameras should be placed to adequately capture co-workers' posture, eye gaze, body language, and gestures that accompany communication [8,9,24,26]. Such acts are critical for video-mediated conversations because they augment speech with necessary contextual cues [8]. Thus, mirror views of oneself have been shown to be important in order to ensure users can see one's body language and gestures [16]. Video communication systems often face privacy challenges because users can easily stand out of a camera's view but still be able to see or hear remote users [2,4,5]. Thus, it can be difficult to know who at a remote location can see or hear you [2,4,5,18].

In domestic settings, video conferencing systems are often very difficult for users to setup and it can be difficult to maintain a connection long term [1,14]. The location of cameras and displays become critical as this dictates what can be seen (or not) and how the system supports conversation, awareness of remote parties, and the privacy expectations of users [11,17]. Adequate lighting can also be a major issue in home-based video conferencing [19]. Research has shown that multiple cameras and displays are often needed in order to capture a variety of activities that are typically non-stationary [17,19,20]. Similarly, we see the need to design for portable displays that can easily be moved between locations or to target different specific activities [12,17]. In cases where a family member is suffering from chronic illness, there is often a desire to *not* be shown on camera because of patient sensitivity [21].

## STUDY METHODOLOGY

The goal of our study was to understand how doctors and patients used non-portable video-based telemedicine systems and how the design affected consultations. We undertook a qualitative approach where our study was exploratory in nature.

### Participants

We recruited eight participants: four health providers and four patients. Five participants were male and three were female. Patients were between 50 and 75 years old and health providers were between 30 and 65 years of age. All participants resided in cities or towns within the same geographic region of Canada. Health providers had at least several years of experience in their profession. All four health providers and one patient had prior experience using the telehealth system. Two patients were involved in renal consultations and two patients had cardiology consultations.

## Method

In total, we conducted four *in situ* observations of consultations between the patients and remote healthcare professionals to observe the ways in which they made use of the telemedicine systems. Consultations took place within cities in Canada using the same telemedicine system but in two different rooms. Observations focused on the ways in which the health professionals and patients interact with each other and the telemedicine system. We observed two consultations from the health provider side and two from the patient side. Observations began when the patient entered the telehealth teleconferencing room and ended once the patient had left the teleconferencing room. Thus interactions before and after teleconferencing were also observed so we could see how video calls were initiated and ended. Consultations lasted roughly one hour each.

Following the observations, we performed semi-structured interviews with patients and providers. Interviews were conducted individually to maintain privacy and focused on identifying critical incidents in technology usage. Interview questions for health providers included general questions such as, "Tell me how you use the system to support your consultations" and specific questions such as, "Describe how you show portions of the patient's body when using the telemedicine system." Patients were asked interview questions, such as: "Tell me about a situation where the system worked well" and "Tell me about any problems, if any, that you experienced when using the system."

### Telemedicine Setup

Consultation rooms were relatively small in size, approximately 150 square feet, and connected to a similar room at the remote location. One room contained the patient and a nurse, while the other room contained the remote specialist. All used a non-portable telemedicine system that contained a 20" HD display. This display was connected to a computer and video conferencing camera (Full HD Polycom Eagle-Eye III) that streamed video at 1920 x 1080p with frame rates varying between 20 and 30 fps depending on latency. The camera was placed at the top of each display. The user interface of the system showed the remote view across the majority of the screen and a smaller view containing either diagnostic information or a mirrored view of the local room. Health providers had to toggle between the two and could not show both at the same time. Patients sat between 5 and 8 feet from the camera given the placement of furniture in the rooms. The accompanying nurses always sat off-camera.

### Data Collection and Analysis

All data was collected in the form of handwritten notes and sketches as we were not permitted to capture audio or video of the consultations due to patient confidentiality. We used open, axial, and selective coding [23] to analyze our interview and observational notes for each participant.

Our analysis revealed four salient themes that illustrate the challenges that patients or health professionals faced when using the health system. We step through these now.

### **Privacy and Awareness**

First, challenges emerged relating to privacy issues and an awareness of who was around and privy to seeing or hearing the video consultation. A similar problem was found in workplace media spaces [2,4,5,8]; however, we now see it occurring in a different context where unlike work offices, there is typically a greater expectation of privacy due to the sensitive nature of consultations. Yet what we found in our observations was a general sense by health providers that because the consultation was occurring in a specialized room behind closed doors, concerns about privacy were already a non-issue.

This was not the case though. Instead, the video setup created new challenges because the camera's view did not capture one's entire surroundings. This meant that patients did not have a sense of the room layout nor what was happening off camera. This challenge was exacerbated because patients had never seen the consultation room at the remote location. For example, patients did not know if anybody else was in the room, if others were also watching the consultation, or if the room doors were open. This issue was best exemplified by P4 who, halfway through his consultation behind closed doors, asked, "Is the room to the door open?"

Even though the cameras offered high definition video, patients lacked awareness of who they were talking to even for those people that were visible on camera. The video view was too small to show badge names and health providers did not always tell the patient his or her name.

Unlike findings from workplace and home usage of video conferencing systems [4,21], patients were not concerned about how they looked on camera, despite sharing potentially sensitive views of their body. This contrasts research that shows family members facing chronic illnesses do not typically like to use video chat [21].

### **Body Language and Gestures**

Second, body language and hand gestures were difficult to capture and see over the telemedicine video link. Such acts are important in workplace communication because they provide additional cues and information that accompanies speech [8]. As a result, one often relies on a mirror view to know that gestures are being shown accurately [16].

We observed that both health providers and patients used a large amount of hand and body language to communicate but a majority of this communication was not captured by the telemedicine system's camera. For example, one health provider used her fingers to list off items but none of these physical actions were seen by the remote patient. Health providers also gave physical instructions, such as, "If you were to take your finger and push into your leg, would you sense a flare up?" (a question related to gout). They would

then try to show the patient instructions visually by pressing on their own arm. Again, this was not always visible on camera.

Following the consultation, we asked health providers about their use of gestures and whether they thought the patient could see them. Health providers assumed that patients could see everything they did and they typically did not look at the mirror view of themselves in the system to know for sure. It was hard to remember to do so and also cumbersome. Sometimes this view was replaced by diagnostic information. Other times the providers were too busy focusing on the patient to notice their mirror view. Thus, the consultation was too cognitively demanding already that one's own video view was not a primary concern.

We also found that camera angles created inadvertent body language and suggestions of social dominance. In all consultations, the health providers sat close to the telemedicine system, and based on the position of the camera, it was common for the health providers to stare down into the camera. This created a sense of power and dominance, as reported in other literature [8]. While cameras could be moved or offer zoom capabilities, these features were not often used in our observations because of the difficulty in doing so. It was also challenging to determine the level of openness and comfort of the health providers as most of the time only their faces were displayed. Such openness is often conveyed through body language, e.g., not folding arms, facing the other person directly. The patients, on the other hand, sat facing open and comfortably on a leather reclining chair.

### **Emotions**

Third, consultations were of an emotional nature where people were learning about a potentially serious health condition. Health providers had a challenging time discerning the emotional reactions of their patients to diagnoses and some failed to notice patients who were concerned about what they heard. Again, this was despite the video transmitting at a high definition. They also had difficulties making eye contact to show they were paying attention to the patient's needs because of the displacement between the camera and video display; such a problem is also widely reported in the video communications literature more generally [8,24].

For example, during one consultation, a health provider prescribed a particular drug for pain to the patient, and being physically present in the room, we sensed that the patient felt uncomfortable with the health provider's recommendation and his concerns about possible addiction. This was evident through his body language and facial expressions. Based on the conversation, it was apparent that the health provider could not sense the emotional discomfort in the patient. Luckily, during this consultation the nurse who was present in the room noticed the patient's concern. Following the consultation, the nurse brought this

conversation back up with the patient and was more comforting.

### **Playfulness and Humor**

Lastly, and perhaps most unexpected, we found that both health providers and patients often communicated through jokes and associated facial expressions. Despite the seriousness of the appointment and consultation, humor was used by some participants (both patients and providers) to ‘lighten the air’ and make the patient feel more comfortable. For instance, P3, a patient, often used dead-pan humor by making subtle comments and jokes while keeping a mostly straight face.

However, the challenge we observed was that such humor and playfulness could easily go unnoticed. While this could have simply reflected a natural social interaction where one simply does not notice some instances of humor, it was also evident that participants did not see subtle changes in facial expressions such as mild smiles or changes in vocal pitches that might suggest humor and a sense of play.

### **DISCUSSION AND CONCLUSIONS**

Overall, we found that the video-based telemedicine systems that we studied created challenges for both patients and health providers. Interestingly, many suggestions for improvement can be found in the literature on workplace media spaces and domestic video communications. Suggestions include providing mirror views of one’s own video [12,16], using multiple cameras or viewpoints [19,20], making use of portable cameras or devices that can be easily moved to capture different regions of a space [12], using multiple displays [19], using wide field-of-view cameras, or considering the placement of users in relation to cameras [4,5].

The fact that many suggestions for design improvements can be found in the past CSCW literature, a lot of which is over twenty years old, suggests a myriad of broader challenges. This finding could reflect: the amount of time it takes research to move into practice and commercial technology design; a lack of awareness of CSCW research in the telemedicine community; or, the additional challenges that a health context places on telepresence systems. We believe it is likely a combination of all these situations (and more), though the latter is particularly pertinent to our study.

Our research has shown that telemedicine settings bring with them unique challenges when it comes to telepresence and it may not be as straightforward as one thinks to simply implement suggestions from broader research on video-mediated communications in a health context. For example, it would seem fairly obvious that mirror displays so people can correctly convey body language over a video link would be critical. Yet providing such features is not as straightforward as it might seem. We found mirror views in the context of health consultations to be challenging to

use because of the cognitive demands of the consultations. There are also screen real estate issues in terms of having the space to show a mirror view when competing with other diagnostic information. This raises the design challenge of reconsidering how mirror displays should be created for telemedicine systems, or, more broadly speaking, rethinking how designs can be created to ensure an entire user’s body is visible on camera (perhaps even without mirror displays). Health providers may also not think about things such as orienting one’s body so it is fully visible on camera and likely neither will patients. This means additional onus is placed on the design to ensure that users are aware of how they should position themselves to be fully on-camera along with designs that make it easier to do so.

We also learned that even with small rooms and closed doors, privacy is an issue in terms of knowing who is present and able to see or hear the content being streamed. The closed door of the consultation room inadvertently seems to create a misconstrued sense of privacy on the part of health providers. However, we recognize that health providers are focused on the consultation perhaps as opposed to ensuring privacy when it comes to technology usage. Here they are not likely to recognize the potential for privacy issues that have been documented at large in the CSCW literature. This suggests that designs may benefit from mechanisms that highlight potential privacy issues to patients and providers so that they may become more knowledgeable and perhaps even try to remedy such situations themselves.

Video-based telemedicine systems should also consider the ways in which emotions, playfulness, and humor can be conveyed over video and audio links. Even with high fidelity video, such attributes and behaviors can be difficult to detect. Moreover, video angles can inadvertently create power dynamics if one is looking down or up into a camera [9]. Past research has also shown that people do not typically like to use video communication systems with family if they are suffering from health issues [21]. In the case of health consultations, they may have no choice. This creates another open design opportunity for exploring how telepresence systems can better support the emotional exchanges that are often present in health consultations.

### **Limitations**

Our study is limited in that we only studied one type of video-based telemedicine setup. While it is likely that other hospitals or health centers use similar non-portable telemedicine setups, this is not guaranteed. We also had a limited sample size of only four patients and four health providers. This is not enough to generalize our results to other patients and providers, however, it does allow us to raise concerns around several areas of design that should be noted as being potentially sensitive and problematic for telemedicine systems. These suggest open opportunities for technology design explorations and research.

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