Exploring Video Conferencing for Doctor Appointments in the Home

by
Dongqi Han

M.Sc., Institute of Software, Chinese Academy of Sciences, 2017

B.Sc., Beijing Normal University, 2014

Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of
Doctor of Philosophy

in the
School of Interactive Arts and Technology
Faculty of Communication, Art and Technology

SIMON FRASER UNIVERSITY
Fall 2022

Declaration of Committee

Name:	**Dongqi Han**
Degree:	**Doctor of Philosophy**
Title:	**Exploring Video Conferencing for Doctor Appointments in the Home**
Committee:	**Chair: Brian Fisher** Professor, Interactive Arts and Technology
	Carman Neustaedter Supervisor Professor, Interactive Arts and Technology
	Wolfgang Stuerzlinger Committee Member Professor, Interactive Arts and Technology
	Halil Erhan Examiner Associate Professor, Interactive Arts and Technology
	Xianghua (Sharon) Ding External Examiner Senior Lecturer, Computer Science University of Glasgow

Ethics Statement

The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

a. human research ethics approval from the Simon Fraser University Office of Research Ethics

or

b. advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University

or has conducted the research

c. as a co-investigator, collaborator, or research assistant in a research project approved in advance.

A copy of the approval letter has been filed with the Theses Office of the University Library at the time of submission of this thesis or project.

The original application for approval and letter of approval are filed with the relevant offices. Inquiries may be directed to those authorities.

Abstract

This thesis explores the use of video conferencing for doctor appointments in home settings. We are now seeing a shift with the proliferation of commercial technologies, such as smartphone apps that allow people to have appointments with family doctors from nearly any location for various reasons. However, little is known about how doctors and patients perceive smartphone-based video appointment systems, what types of medical ailments are best suited for these systems, what socio-technical challenges might emerge through their usage, and how systems should be designed to support the virtual appointment context. This work aims to understand patients' and doctors' needs and investigate what design factors are important in designing video conferencing systems to support patients seeing the doctor from their homes.

This thesis consists of three studies and the design of a prototype system. I first conducted an exploratory study that investigated the needs of doctors and patients for video conferencing to support doctor appointments with a range of medical situations. Then, I conducted a participatory design study that included patients as partners participating in the system design process and created the prototype Dr.'s Eye with an iterative design process. Third, I evaluated how patients used the video conferencing prototype in various medical situations utilizing scenario-based interviews where patient participants attended mock video doctor appointments. The study was to understand the benefits and challenges of using specially designed features to support these varying scenarios.

Overall, my work contributes an empirical understanding of conducting varying types of doctor appointments over video in home settings and an understanding of design factors that should be valued in future system design to overcome interaction issues for both technical and socio-technical aspects during video doctor appointments, including camera work to support patients capturing body areas and actions, coordination work allowing the doctor to examine patients with authorized camera control, privacy protection to comfort patients' experience in exposing private body regions, as well as doctor-patient trust relationship creation and maintenance.

Keywords: Video Doctor Appointment; Video-Mediated Communication; Tele-healthcare; Domestic Setting; Mobile Interaction

This dissertation is dedicated to my parents.

For their unconditional love and support.

Acknowledgements

I would like to express my sincere gratitude to Dr. Carman Neustaedter, my senior supervisor. Thank you for always being supportive and patient. I could not get to this point without you cheering me up. You are a paragon of outstanding mentorship. I have learnt a lot from you. I deeply admire your creative ideas, self-discipline, and passion for research. I have had an enjoyable graduate life over these years because of you. Words are powerless to express what you have meant to me.

I would like to thank Dr. Wolfgang Stuerzlinger, my supervisor, for your insightful guidance on my work. Your feedback always hits the nail on the head. I truly appreciate your thorough and timely review of my writing, no matter how tight the time was. Additionally, I would like to thank Dr. Halil Erhan and Dr. Xianghua (Sharon) Ding, as my internal and external examiners, for taking the time to read my thesis.

I would like to thank Dr. Denise Geiskkovitch, Dr. Yasamin Heshmat, Chelsea Mills, Dr. Irene Ye Yuan, and Amy Yo Sue Chen, for the fantastic work helping me with running studies and paper writing. I want to especially thank Ce Zhong for the 3D modelling and printing work day and night so that I could initiate the study in time.

I would like to thank other Connection Lab pals, Punyashlok Dash, Dr. Brennan Jones, and Hanieh Shakeri, for creating a warm and supportive group. I will miss the time we hang out together.

I would like to thank all the individuals who participated in my studies. You contribute to the basis of my research. This thesis is impossible without your kind support.

Table of Contents

List of Tables

List of Figures

Chapter 1.

Introduction

Telemedicine involves the use of video conferencing technologies to distribute healthcare services over distance without patients being physically present in the healthcare facilities. Video telemedicine can be valuable in supporting patients who might face difficulties seeing a doctor in person, such as those with chronic illnesses or mobility issues (Mehrotra *et al.*, 2016). Nowadays, telemedicine systems have been widely applied within a variety of subspecialties, including but not limited to tele-psychiatry (Shore, 2013), teledermatology (Lee and English, 2018), and telephysiotherapy (Aggarwal *et al.*, 2016), incorporating video conferencing to share health information to doctors. With the prevalence of video communication technologies, telemedicine systems now aim to support a more extensive range of video appointments that move beyond just specialist consultations (Taylor *et al.*, 2015; Carter *et al.*, 2018).

Recently, it has become more prevalent to see a doctor over video using one's smartphone without the need to visit the doctor's office. The spread of COVID-19 has also encouraged the general practice of video conferences for doctor appointments. Virtual visits have helped decrease the risk of passing on the virus as there is no physical contact between patients and healthcare professionals (Li *et al.*, 2020). Moreover, seeing the doctor online can help patients save travelling and waiting time in clinics during in-person visits.

A list of commercial applications for video doctor consultations, such as Telus Babylon (Figure 1.1), VSee, Medeo, etc., have emerged across North America, and provide secure video connection services for family doctor appointments. For example, TELUS Babylon provides nationwide video appointment services in Canada, where patients can select a time slot at the appropriate time. A doctor then initiates a video call with the patient on their smartphones. Only one phone camera can be used at a time, though users can toggle between front and rear-facing cameras on their smartphone. Appointments are audio recorded for records and the safety of the patient. Babylon is marketed for appointments about infectious, psychiatric, digestive, dermatologic, and traumatic situations, as well as for providing medical advice regarding sexual health, lifestyles, or medications.

Figure 1.1 TELUS Babylon provides a doctor appointment via a smartphone app

Video-mediated doctor consultations have been studied substantially in the fields of medicine and human-computer interaction (e.g.,(Sevean *et al.*, 2009; Kvedar, Coye and Everett, 2014; Armfield, Bradford and Bradford, 2015; Weinstein, Krupinski and Doarn, 2018)). The evaluation of video appointments has commonly focused on medical outcomes, for example, coordination and administration of online appointments (Shaw *et al.*, 2018; Chudner *et al.*, 2019), patients' acceptance and satisfaction (Sevean *et al.*, 2009), as well as the performance compared with face-to-face consultations (Taylor *et al.*, 2015). Explorations of telemedicine technologies in human-computer interaction and related fields have involved studies of the quality of light, image resolution, sound and video lag (LeRouge, Garfield and Hevner, 2002). Studies of video consultations for supporting primary healthcare have looked at similar outcomes with respect to acceptance, feasibility, coordination, satisfaction or accessibility (Rho, Choi and Lee, 2014; Bashshur *et al.*, 2016). However, these investigations have not included detailed explorations of how technology could change the outcomes of consultations from both technical and social perspectives, how doctors and their patients might want to use video conferencing for different types of doctor's visits, and how the video system should be designed to support the virtual doctor appointment context. For these reasons, I explore doctors' and patients' reactions to using video conferencing for a diverse set of medical appointments with a focus on uncovering design and user experience knowledge. This work also investigates how to design video systems to support varying types of body exams in home settings through the evaluation of a video conferencing prototype specifically designed for the virtual appointment context.

To begin with, I describe the context of my research. Then, I introduce research questions, motivations, objectives, and methods to address these questions. Afterward, I provide an overview of the thesis chapters.

1.1. Research Context

This work focuses on understanding the usage of video conferencing systems for family doctor appointments in home settings and contributing to design implications for creating video systems to support such appointments. The research falls within the field of Human-Computer Interaction (HCI). HCI studies the interaction between humans and computers, which covers both technical aspects, such as user interface design and interaction techniques, and human factors, involving sociology, psychology, and cognitive science (MacKenzie, 2013). More specifically, my work is situated in the field of video-mediated communication for healthcare (Figure 1.2). Video communication has broad study contexts. For example, video communication can support casual conversations in domestic life (Kirk, Sellen and Cao, 2010), formal meetings in the workplace (Henderson, 2009), or other types of collaborations in the media space (Speicher *et al.*, 2018). There is also a large volume of literature on healthcare, which looks into communication barriers and brings up strategies to enhance the quality of doctor-patient communication (Miller, 2003; Chandwani and De, 2013; Lim *et al.*, 2016), focuses on marginalized populations, such as older adults using video technology (Rodeschini, 2011; Castanho, Sousa and Santos, 2017), or explores technologies to collect patients' health data (Farahani *et al.*, 2018). These domains are not covered in my work in order to scope it. My research focuses on understanding doctors' and patients' interactions with video conferencing systems and generating design factors of the video system to support their usage. Yet, my work is limited in that it does not investigate actual doctor appointments in real life. The rationale is further discussed in subsequent chapters.

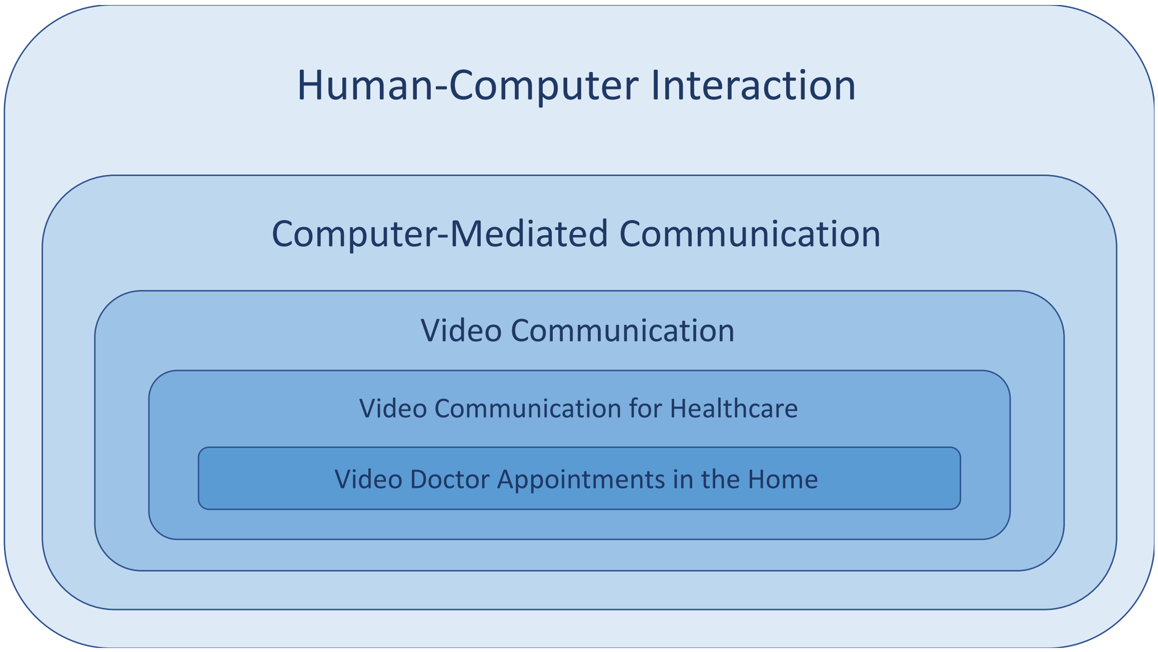

Figure 1.2 The context of my research which is within the domain of video-mediated communication and telehealthcare

1.2. Research Questions

The overarching goal of this thesis is to address the following research problem:

RQ: How should we design video conferencing systems to support doctor appointments in home settings with patients?

The evaluation of video consultations has commonly focused on the coordination and administration of online appointments (Shaw *et al.*, 2018; Chudner *et al.*, 2019), patients' acceptance and satisfaction (Sevean *et al.*, 2009), as well as the performance, compared with face-to-face consultations (Taylor *et al.*, 2015). There is limited research on detailed explorations of how technology could change the conduct of appointments from both technical and social perspectives. Further, commercial video conferencing systems like Skype or specialized systems like Telus Babylon have been introduced in recent years to support family doctor appointments. Despite that, there is little research to explore how doctors and patients use them, with an emphasis on user interface design issues. Current video consultation applications are designed based on video systems for general communication. They have not adopted the design for examinations of different areas of a person's body over video. There is also a lack of knowledge on how to properly conduct exams that focus on private areas of the body. Although design challenges such as showing patients' bodies, issues of light quality, sound, and video lag have been mentioned in previous work (LeRouge, Garfield and Hevner, 2002; Aggarwal *et al.*, 2016), few designs have been proposed particularly to address these challenges. This motivates my research on how to best design video conferencing systems for doctor consultations that involve a home setting.

To answer my main research question, I break it down into the following sub-questions.

RQ 1: What are the needs of patients and doctors for video conferencing systems focused on home-based doctor appointments?

Doctor appointments over video typically include asking for patients' symptoms, visually inspecting patients' body parts, and making decisions. Previous research has studied actual video-based doctor appointments. For example, Powell et al. (Powell *et al.*, 2017) interviewed patients after having video-based appointments in a clinic. Patients reported only minor privacy concerns with people overhearing the call. Dixon and Stahl (Dixon and Stahl, 2008) rated patients' experiences using video visits compared to in-person visits. In all cases, they did not explore the capability of video appointments and the corresponding needs of patients, as well as possible concerns. The specific home context has also not been considered in previous studies. Doctors may share different opinions compared to patients' thoughts in terms of varying types of medical situations over video. Previous studies have revealed that doctors tend to treat health conditions as a scientific phenomenon, and they focus more on how to examine and treat patients properly, while patients focus more on subjective feelings in relation to how their health conditions could affect their personal life (Andersen *et al.*, 2014; Rajabiyazdi *et al.*, 2017). Thus, it is important to understand design needs and challenges from both doctors' and patients' perspectives. Further, explorations of video doctor appointments have shown challenges with conducting examinations on patients over video due to the limitations of camera work (capturing the right view in the camera) or physical interactions (LeRouge, Garfield and Hevner, 2002; Li, 2013; Kvedar, Coye and Everett, 2014). However, little research has investigated detailed barriers based on specific contexts and explored technologies in the home setting to support doctors during appointments for varying medical situations. Therefore, I studied patients' and doctors' use of video conferencing for varying medical situations.

In order to answer this question, I chose semi-structured interviews and a scenario-based design method to gain an in-depth understanding of patients' and doctors' thoughts about using video conferences for their appointments. Twenty-one patients and twelve family doctors were recruited to conduct the study. They were interviewed about their past appointment experiences, and reactions to six video scenarios we designed that covered a range of medical situations.

Results showed that existing commercial video conferencing systems (e.g., Skype or Babylon) were not mapped well to the needs of patients and doctors for video-based appointments. Although participants valued improved accessibility of seeing doctors over video, they also showed a series of concerns. They worried that building trust relationships, and delivering empathy could be challenging via video calls because the body language could not be adequately conveyed with a general video camera. They also felt it was challenging to show patients' different body regions and be examined over video compared with seeing the doctor in person. Privacy concerns were also notable in revealing private body parts, talking about sensitive topics, giving doctors additional camera control, as well as confidentiality in that the conversation could be accessed by third parties. Our work suggests that systems designed for video-based doctor appointments should include support for capturing different body parts and actions; enhancing the physical embodiment of both patients and doctors to help build relationships; and designing better camera control to protect patients' privacy.

Building on this work, I designed a video conferencing prototype trying to address the challenges that surfaced in this study. This is presented in the following research question.

RQ 2: What design factors are important for designing video conferencing systems that can meet the needs of varying types of body examinations in the home setting?

Current studies on video-doctor appointments have expanded the use of video conferencing for a broad spectrum of medical situations. Yet, their user interface is akin to existing video applications such as Zoom for general communication. The exploratory study conducted with family doctors and patients as part of this dissertation suggests particular needs for the virtual doctor appointment context. Furthermore, there is a lack of systematic understanding to guide the design of video systems that can support a range of situations that could happen during video appointments. The situations commonly include patients and doctors talking about health conditions or treatment plans, patients describing symptoms by showing body parts or gestures, doctors asking patients to conduct certain actions. These scenarios involve how patients arrange the camera to capture themselves differently during examinations, and how to design the user interface and video control to cope with possible social concerns such as privacy. This motivates my research on how to create video conferencing prototypes to tackle these design challenges.

In order to answer this question, I employed a participatory design method (Spinuzzi, 2005; Sanders, Brandt and Binder, 2010) that involved patients as our design partners. We conducted three design workshops online with a total of six patient participants. All our patient participants had prior video consultation experiences, either due to chronic diseases or acute health issues. Each design workshop involved different activities and goals: the first workshop focused on identifying challenges in the use of video conferencing for doctor appointments; the second focused on brainstorming ideas for the challenges identified in the previous session; and the third emphasized the refinement of design ideas.

Based on the design requirements we uncovered in the participatory design study, I proposed four main features for a system to support various forms of visual doctor inspections:

1) *Decouple the camera and display* to help patients capture a view of their body using an external camera and see the video stream on the phone.

2) *Free capturing* to support placing the camera on a table or attaching it to any other surfaces.

3) *Hide my camera view* to support disabling the video stream sent to the doctor.

4) *Virtual cover* to limit the area that the doctor can see.

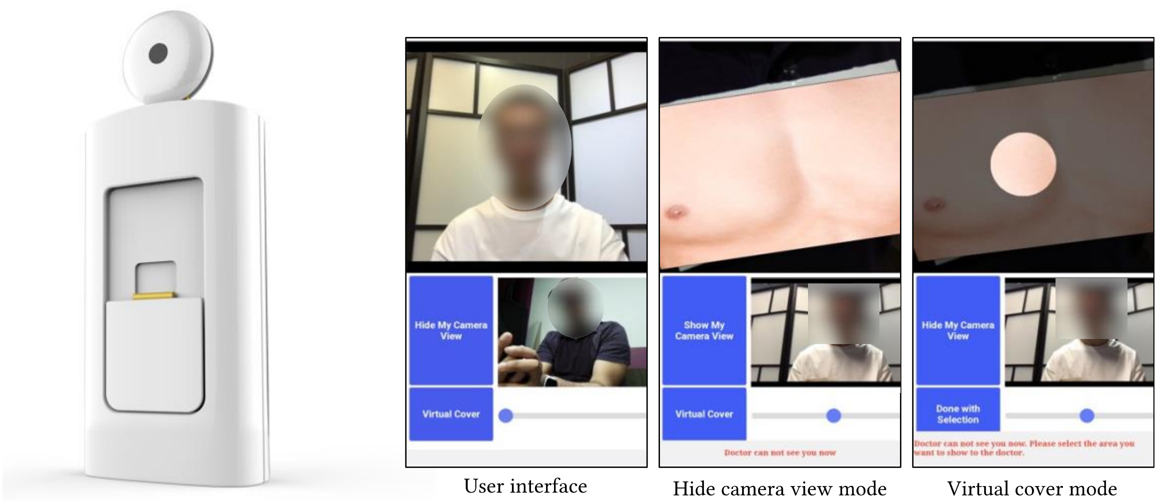

Figure 1.3 Video conference prototype and user interface.

Then, I created the prototype through an iterative design process that included brainstorming, hand sketching, and creating a variety of low-fidelity prototypes, from a folded paper box to the 3D model (Figure 1.3 left). I also created a user interface that patients can use for video calling the doctor (Figure 1.3 right). Patients use a mobile phone and the prototype as the external camera to call the doctor for appointments. In the following research question, I explore how patients would use the prototype for doctor appointments in a home setting.

RQ 3: How will patients use a video conferencing system that is specially designed to support body examinations during doctor appointments, and what are the benefits and challenges when using the system?

To understand how patients make use of a video conferencing prototype designed explicitly for doctor appointments in the home setting, I conducted an exploratory study with eighteen participants who participated in mock video doctor appointments for five medical situations. These scenarios focused on camera work where participants manipulated the camera to show a range of body regions. Scenarios included: diarrhea, sore throat, chronic pain in the knee, chest acne, and post-surgery recovery. I observed how patient participants used our system during these mock scenarios and employed semi-structured interviews to learn about their reactions as well as their thoughts on different features to support capturing their body regions.

The findings showed that decoupling the camera and display provided flexibility for capturing different body regions. Participants valued privacy protection features that could hide their camera view and cover portions of the body that were unnecessary to show to the doctor. Yet, challenges remain in maneuvering two devices simultaneously and coordinating the camera work between the doctor and patient when showing the patient's body. I also found that concerns around showing private body regions were in relation to self-image and the changes from a clinical space to a virtual space. The study points to implications around integrating a decoupled camera and display, supporting camera control distribution, designing visual feedback with camera views, and supporting trust building for video appointments. This work contributes a prototype design of a video calling system for doctors and patients, an empirical understanding of conducting varying types of body exams over video in home settings, and an understanding of design factors that should be valued in future system design to overcome interaction issues for both technical and socio-technical aspects during video doctor appointments.

1.3. Methodological Approach

The exploratory nature of this work leads the study approach to be qualitative. The motivations of my studies are to gain a deep understanding of the challenges of using existing video conferencing systems for doctor appointments, design factors that are valued in the virtual appointment context, and how patients make use of the video system when being examined in different body regions in the home setting. The use of a qualitative approach can help investigate doctors' and patients' reactions to a variety of medical situations during video appointments. In this section, I provide an overview of the approaches used to handle the research questions in Section 1.2.

To address RQ1's objective, I used a scenario-based design method (Carroll, 1999) to mock video doctor appointment scenarios. Scenarios are representations of people using systems so that the use of video conferencing for doctor appointments can be explicitly shown to patient and doctor participants. Scenarios can be very flexible as they can be detached from the low-level details of the system development process. Scenarios are mainly focused on the users' needs, settings, and activities, which can serve as a type of abstraction supporting the design process. In this way, I received feedback from patients and doctors around what they thought was valuable and challenging in various medical situations without the need to investigate actual virtual appointments which could infringe on patients' privacy.

Qualitative data collection can benefit researchers in obtaining multiple data formats to understand participants and phenomena (Creswell and Poth, 2016). In my studies, I used semi-structured interviews, video recordings, and observations to collect user data. Semi-structured interviews offer the advantage of getting a more profound insight from participants by asking follow-up questions. Participants were asked questions that varied according to their individual experiences and unique reactions to different medical situations.

The data analysis process involves organizing, coding, shaping themes, interpreting, and representing (Creswell and Poth, 2016). Transcribed interview data and observation memos were generated into codes. Afterward, these codes were categorized, selected, and higher-level themes were produced. A trait of such an approach is that the data analysis process is subjective based on researchers' viewpoints. The essence of coding is not simply summarizing the data, but looking for unexpected, unusual, or surprising information, which differs from prior literature. I used open coding, axial coding, and selective coding to analyze data from both patient and doctor participants. The data analysis process is dedicated to discovering critical issues that doctors and patients may encounter during video consultations using current video conferencing systems.

The second study focuses on how to design the video system to address the needs of patients and doctors. It is essential to involve end-users in the early stages of a design process, so that researchers can be aware of whether the proposed design solutions are able to meet users' needs in terms of ease of use and socio-technical aspects. The participatory design focuses on involving end-users in the design process. The participatory design derives from constructivism with which knowledge is situated in real contexts and user interactions can be interpreted; this can help the creation of artifacts to meet users' needs (Spinuzzi, 2005; Sanders, Brandt and Binder, 2010). In the context of video doctor appointments, the possible interactions between users (patients and doctors) and different types of video conferencing systems, as well as how they react to these solutions are unclear to researchers. Therefore, the end users were asked to join as co-designers in the participatory design study. They provided valuable information on user interactions, design ideas, and prototype feedback throughout the design process.

The third study is to evaluate the video system specially designed for the home-based doctor appointment context. I used the scenario-based design and user enactment method (Carroll, 2000; Odom *et al.*, 2012). User enactment is aimed at simulating life experiences with novel technical interventions, which could be radical. Researchers build a physical space with social contexts in the lab environment. I designed a list of scenarios where a range of medical situations was presented. Participants enacted patients as described in each scenario using the video conferencing prototype designed for doctor appointments.

1.4. Organization

This work explores video conferencing for doctor appointments in the home setting. Three studies are described, followed by the discussion that emerges from these three studies.

The first chapter gives a brief introduction to this thesis, including research context, research questions, and methodological approaches applied in the studies.

The second chapter is a literature review which describes related work regarding telehealth care, and video-mediated communication. In this chapter, different telemedicine systems for remote healthcare are introduced. Video communication in the fields of human-computer interaction and computer-supported cooperative work are also described.

The third chapter presents an exploratory study that investigates doctors' and patients' thoughts on video-based appointments for a range of medical situations. This chapter reveals the design needs of the video system to support virtual appointments in the home setting.

The fourth chapter introduces a participatory design study that involves patients participating in the system design process. Design requirements are generated after workshops to guide the design of a video conferencing prototype. Then, the chapter describes the design process of a video conferencing prototype, Dr.'s Eye, and detailed features of the prototype.

The fifth chapter reports on an evaluation study on how patients use the video system specially designed for the doctor appointment context. The chapter describes the results of what are valued by patients in the use of the video conferencing prototype.

The sixth chapter concludes the works from this thesis, summarizes contributions from all the studies, and points to design implications. In the end, the chapter brings up future work.

Chapter 2.

Related Work

In this chapter, I present related work in the field of healthcare over distance and video communication in general. First, I introduce how healthcare services are distributed over distance with telecommunication technologies. This involves conducting physical examinations on patients and visually inspecting patients conditions. Doctor-patient communication also plays an essential part, which impacts the quality of healthcare. Next, I describe video communication in general contexts, including the workplace and home life. I break this topic into three aspects: virtual presence, collaborative activities, and privacy. Each of them details the challenges of designing for different contexts and prior work to address them.

2.1. Healthcare over Distance

Telecommunication technologies can distribute healthcare services over distance without patients and doctors being physically present in the same space (Miller, 2001). Video conferencing allows patients who face challenges in visiting clinics in person, e.g., physical disabilities, or who need long-term healthcare, e.g., chronic illness, to see doctors in their own homes (Steel, Cox and Garry, 2011; Mehrotra *et al.*, 2016). With the prevalence of video communication, video telemedicine is aimed at supporting a broad spectrum of medical situations. A range of medical specialties uses video conferencing to provide better healthcare, such as dermatology (Lee and English, 2018), psychiatry (Shore, 2013), physiotherapy (Dillman, Tang and Tang, 2016), neonatology (Robinson *et al.*, 2016), and post-surgical consultations (Canon *et al.*, 2014). It can save patients' time travelling to the doctor's office. Doctors use telehealthcare technologies to track patients' health conditions. In this section, I describe how the communication and interaction between doctors and patients could differ from face-to-face visits.

2.1.1. Conducting Physical Exams from Home

In face-to-face appointments, doctors use medical instruments (e.g., a stethoscope), perform auscultations (e.g., listening to one's lungs) or palpations (e.g., pressing on a patient's abdomen) to look for clues that could lead to patients' symptoms. Novel approaches have been created to adapt these procedures to exams over distance.

Using Peripheral Professional Medical Instruments

In a face-to-face encounter, a family doctor is equipped with a set of medical instruments in their exam room, such as a blood pressure cuff, stethoscope, or otoscope, to examine necessary physiological information. Specialists may have more professional equipment for particular purposes. People with chronic diseases may have life support equipment or health monitoring devices in their homes (Casavant *et al.*, 2014; Farahani *et al.*, 2018). Yet, general patients may not have such instruments, so letting them listen to their hearts is certainly not feasible.

Digital medical devices could make a remote examination possible. Vsee can support a range of digitalized medical equipment, such as the stethoscope, otoscope, ultrasound, and electrocardiogram (VSee, 2020). It supports video-based teleconsultations between health professionals, or between doctors and patients, where the audio or images captured by these devices can be transmitted to remote doctors in real time. Although research shows that the precision of such digital devices is equivalent to traditional ones (Swarup and Makaryus, 2018), there is little research on how patients use these devices when using video appointments. Thus, it would be unknown if patients could use them properly. A study of teledermatology suggests the necessity of high-quality images for accurate diagnosis (Landow *et al.*, 2014). Yet, there is a lack of knowledge to understand how people could capture images effectively using their devices regardless of mobile phones or digital medical instruments. This could raise the need to assist the usability of different devices as well as their affordability in patients' homes.

Conducting Palpations

Doctors are trained to do palpations on patients. Palpation allows doctors to get feedback from patients, such as the tightness of the patient's tissue, body inflammation (e.g., swollen, painful symptoms), or skin temperature (Aggarwal *et al.*, 2016; Seuren *et al.*, 2020; Ansary, Martinez and Scott, 2021). Video conferencing limits the capability of receiving tactile feedback, not to mention the nuanced feedback needed for medical assessment. The limitation is believed to be one of the most challenging factors impeding the deployment of doctor appointments over video (Miller, 2003; Dixon and Stahl, 2008; Aggarwal *et al.*, 2016; Arent *et al.*, 2017; Hammersley *et al.*, 2019). Therefore, doctors have to try alternative ways; for example, verbally instructing patients to palpate themselves (Seuren *et al.*, 2020). Oral examinations may require patients to act according to the doctor’s verbal instructions (e.g., pressing on where patients are asked for), showing their body parts or body postures to the doctor via video cameras, and describing their feelings when performing different actions (e.g., if there is pain; what tolerance level it is) (Seuren *et al.*, 2020; Hansen *et al.*, 2021). Patients may not be able to accomplish what they are asked for precisely due to fear of pain; then, doctors would not get sufficient information as they do in a face-to-face physical examination. As a consequence, they may have to arrange another in-person appointment. The video appointment would be a waste of time for both the patient and the doctor.

Figure 2.1 An example of showing one’s leg to the doctor over video (Seuren *et al.*, 2020)

The current practice of video-based physical exams tends to involve patients with stable medical conditions, and physical exams can be easily performed and observed (Seuren *et al.*, 2020). For example, patients with fluid retention symptoms could be examined remotely (Seuren *et al.*, 2020). The examination of fluid retention is simple. Patients only need to press on their swollen legs, which differs from previously mentioned exams that involve reporting feelings of tightness or pain (Figure 2.1). The assessment is given to remote health professionals that patients only need to show their legs through cameras (Seuren *et al.*, 2020). Yet, video conferencing using a mobile phone or a laptop, in this case, might not be the optimal solution, because pressing on the legs would need the stability of the camera, while showing the leg area needs to reposition the camera. Therefore, two design factors could be necessary for video consultation systems. First, it is necessary to screen out physical exams that cannot be conducted virtually to avoid the misuse of video appointments. Second, the system could support remote examinations when doctors are capable of verbally and visually instructing patients to perform specific movements in an efficient way. Moreover, patients could provide visual feedback quickly and let doctors evaluate their situations precisely.

Figure 2.2 A telepresence robot with an arm to examine patients remotely (Arent *et al.*, 2017)

In general, video-based doctor appointments currently cannot be a replacement for in-person appointments that require physical examinations. The affordability of digital medical instruments might increase the chance of conducting appointments over video. However, the validity and usability of these devices need to be examined in future studies. Physical exams relying on tactile feedback might need careful screening for video visits. It also indicates design opportunities for video systems to better support visual instructions and feedback when patients need to perform exams in their homes. Other attempts, such as using robots for medical examinations over distance (Arent *et al.*, 2017), might not be applicable in a home setting due to their limited accessibility (Figure 2.2).

2.1.2. Visually Inspecting Patients via Video Camera

Doctors rely on a series of visual clues to understand patients' health conditions and their severity. These clues include patients' body postures, movements, and visual cues on their bodies (Gordon *et al.*, 2020). Observing all the visible signs precisely and thoroughly is essential to diagnosis and following treatment. Video conferencing could limit the capability of doctors to observe these fine details because of its technical barriers and interruption of conventional face-to-face consultation phases. Physiotherapy, psychiatry, and dermatology are three fields that have been commonly studied for video-based appointments (Shore, 2013; Landow *et al.*, 2014; Tang *et al.*, 2015; Aggarwal *et al.*, 2016, 2017; Lee and English, 2018). Appointments in such specializations involve using body language and showing patients' skin or body movement. In this section, I introduce these interactions during video doctor appointments.

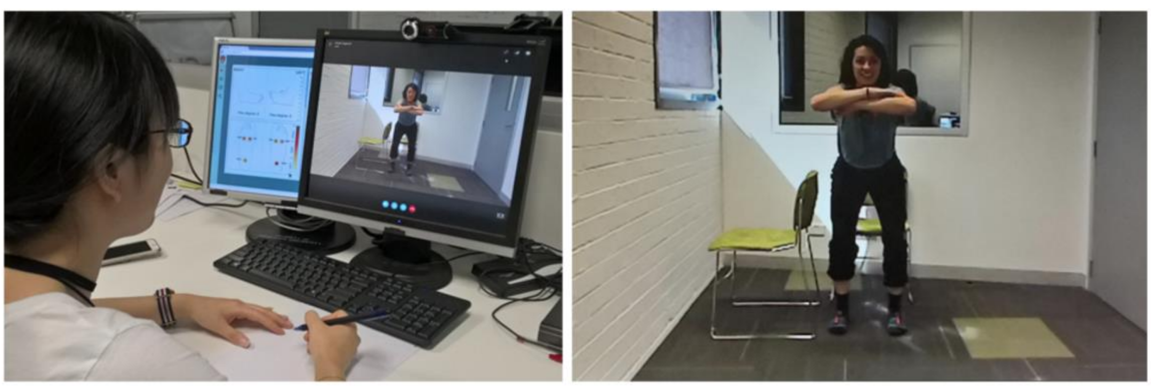

Figure 2.3 Showing one's body gestures to the doctor in a video call (Aggarwal *et al.*, 2017)

First, a limited field of view could hinder doctors from seeing patients' entire bodies. Patients suffering from chronic pain usually join physiotherapy sessions to improve their conditions (Aggarwal *et al.*, 2017). They could be instructed to perform a series of physical exercises, such as bending, twisting, or squatting (Figure 2.3). Doctors can observe patients' whole-body gestures in a face-to-face consultation with no obstacles. Yet, an ordinary video conference using phones or desktop computers tends only to show people's faces or upper bodies at most (Al Hussona *et al.*, 2020). Patients have to stand away from the camera far enough to have their entire body within the camera view. Nevertheless, it would be difficult for patients to see their doctor's visual instructions clearly because the size of a mobile phone's screen or a desktop monitor is generally limited. Thus, a much larger scope of display might be appropriate in such situations (Tang *et al.*, 2015).

Second, limited bandwidth could constrain doctors' ability to observe patients' details. Patients' bodily cues, such as vibrating gestures on the face, tears in their eyes, the untidiness of hairs or clothes, fidgeting behaviors, or fatigue, can indicate significant signals of their health conditions or emotional status (Shore, 2013; Uscher-Pines *et al.*, 2020). Doctors are able to observe these bodily cues in a face-to-face consultation if they sit at an appropriate distance. However, it could be challenging to notice detailed facial expressions or micro changes in body behaviors over video (Hulsbosch *et al.*, 2017; Uscher-Pines *et al.*, 2020). In addition to the limited field of view, the limitation of camera resolution and bandwidth has always been considered challenges for video conferencing systems (Jang-Jaccard *et al.*, 2016). Asynchronous teledermatology refers to sending pre-captured images to dermatologists, while synchronous refers to consultations using video conferencing. In practice, asynchronous teledermatology is more welcomed than synchronous teledermatology, because the video quality is not ideal for doctors to observe skin lesions clearly (Lee and English, 2018).

Third, high mobility might be necessary for video doctor consultations to support doctors observing patients from different positions. An example of a face-to-face physiotherapy session shows that the doctor may need to stand sideways to the patient and watch how far the patient is bending (Hansen *et al.*, 2021). Yet, the doctor is unable to do such observations in a video consultation because the patient's laptop is on a table, and it cannot be repositioned freely when the patient is doing exercises (Aggarwal *et al.*, 2016; Al Hussona *et al.*, 2020). It represents a common challenge in video conferencing systems that mobility could be restricted in a virtual environment (Henderson, 2009). In this case, the remote doctor might desire the autonomy of seeing the patient from different angles. Moreover, guidelines for teledermatology practice also suggest that patients can provide body skin images with multiple angles for sufficient information (Lee and English, 2018). This would require patients to maneuver their mobile phones around a specific skin area to obtain high-quality images. Despite that, there is little knowledge of how patients could take pictures efficiently using their devices at home.

2.1.3. Designing Healthcare Technologies for Older Adults

Reports show a continual increase in the number of older adults worldwide (De Cola *et al.*, 2016). They could suffer from varying types of chronic illnesses such as neurological disorders, heart and lung diseases, chronic pain, or cancer (Lindberg *et al.*, 2013; De Cola *et al.*, 2016), which result in their continuous need of receiving healthcare. A review of studies reveals that a majority of information and communication technology (ICT) applications have been designed specifically to support older people in need of long-term care in the home (Lindberg *et al.*, 2013). Video conferencing provides an opportunity for older patients to consult with health professionals about their health conditions or medical equipment usage; they can also seek education or emotional support (Lindberg *et al.*, 2013).

However, smartphones or computers could be too complicated for elderly people to communicate with others (Wang, 2017). They can struggle with complex settings or the user interface of computers or smartphones (Wang, 2017), which were not adapted to their memory performance and cognitive functions as which decrease with age (Rodeschini, 2011). This might make it challenging for older people to use video conferencing for doctor appointments. Further, the increase in age could come with different levels of disabilities, such as hearing or sight issues (Rodeschini, 2011). Older people may not be able to see a mobile phone’s screen clearly. Their possible hearing issues would also require them to adjust the volume, which might be challenging for them to figure out how to do in the device settings. Moreover, the motor coordination abilities of older people can be slowed down due to illness or degeneracy of their neurological functions (Rodeschini, 2011). They might find it challenging to perform subtle manipulations on a small-size mobile phone, such as sliding, clicking, or zooming.

2.1.4. Doctor-Patient Communication

In this section, I introduce doctor-patient communication via video conferencing and how technologies might improve the quality of information exchange between doctors and patients.

Doctors' and Patients' Perceptions of Healthcare

Information exchange between doctors and patients includes information-giving and information-seeking (Ong *et al.*, 1995). Doctors seek information from patients about their symptoms to make diagnoses and treatment plans, which are then given to patients. Similarly, patients describe their symptoms and receive feedback from doctors. However, doctors and patients share different understandings of what information is crucial for them (Lim *et al.*, 2016). Communication challenges could affect the quality of both face-to-face and video-based doctor appointments. The creation of new technologies for video conferencing might help mitigate these communication challenges.

Patients treat illness as a subjective, personal experience that interferes with their daily activities and interactions with others. In contrast, doctors typically see illness as a scientific phenomenon that can be treated based on a series of medical procedures (Andersen *et al.*, 2014). This could lead to consequences that patients feel dissatisfied with consultations because of not understanding medical terms and explanations. Although doctors are suggested to use common terms and everyday language to talk about patients' situations, the barrier could still be huge due to knowledge differences between doctors and patients (Andersen *et al.*, 2014). Instead, new technologies have been explored to describe medical information with the help of visual representations. For example, AnatOnMe supports projecting anatomy structures on the patient's body to elucidate their injuries and treatment plans (Ni, Karlson and Wigdor, 2011). Physio@home supports visualization overlaid on top of the user's arms to provide visual instructions in physiotherapy sessions (Tang *et al.*, 2015). Similar technologies could be used in video-based doctor appointments where visualized illustrations are shown to patients to help them understand their health conditions better. Video systems like Vsee supports doctors in exhibiting patients' test images (e.g., X-ray) and making annotations on the images. The design is more straightforward to help explain medical information than solely using verbal language.

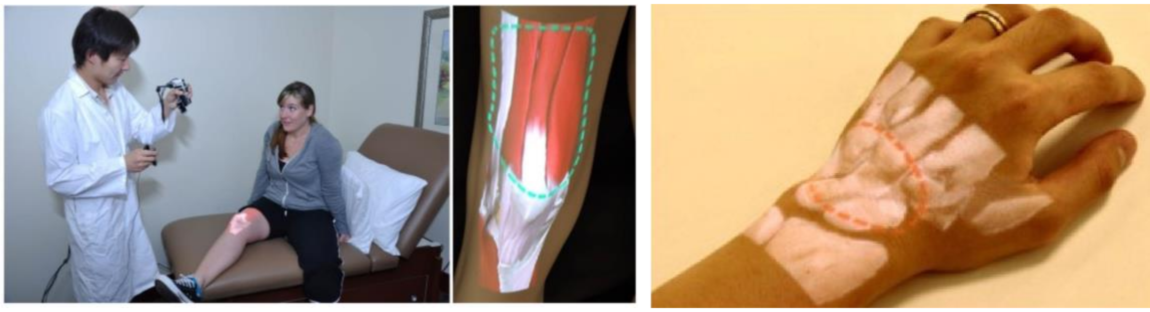

Figure 2.4 An example of providing visual feedback (AnatOnMe) (Ni, Karlson and Wigdor, 2011).

Patients and doctors may share different healthcare priorities, where doctors care more about patients' physical health, whereas patients care more about their personal lives. Patients are concerned about how the diseases and treatment would affect their daily activities or physical abilities (Berry *et al.*, 2017). Yet, sometimes their healthcare providers may not be fully aware of their thoughts, creating discordant healthcare priorities with patients and leading to lower healthcare outcomes (Berry *et al.*, 2017). The information exchange barrier might be associated with a lack of opportunity to talk about patients' concerns or expectations during a consultation. Patients tend to feel stressed because of lacking time to present their medical issues to doctors; this could make them fail to express a complete story and let doctors aware of their full concerns (Rajabiyazdi *et al.*, 2017). Previous research on asynchronous doctor-patient communication, where patients could send messages concerning their physical and emotional thoughts to doctors, reveals that such approaches could help doctors understand patients' worries or attitudes (Andersen *et al.*, 2014).

Doctor-Patient Relationship

A good interpersonal relationship between doctors and patients can build patients' trust in their doctors and produce positive healthcare outcomes, including patients' satisfaction, compliance with treatment, as well as patients' physical and psychiatric health (Ong *et al.*, 1995). Creating high-quality doctor-patient relationships rely on doctors using verbal language and non-verbal behaviors to express warmth, respect, and empathy, as well as giving patients opportunities to express their symptoms, feelings, and expectations (Ong *et al.*, 1995). Doctor-patient communication and interactions for relationship building could be weakened in a video-based consultation.

First, non-verbal interactions for conveying affective support could be affected over video. Non-verbal communication behaviors generally include eye contact, facial expressions, body gestures, and physical touch (Ong *et al.*, 1995). Eye contact in a doctor-patient encounter is essential as it represents that patients' concerns are heard, and doctors show care to patients (Crampton, Reis and Shachak, 2016). Yet, maintaining eye contact can be difficult in a video consultation due to potential misalignments between the focal planes of cameras and the visual planes of users (Grayson and Monk, 2003). For example, if the camera is mounted far from the screen center, even the doctor is looking at the patient on the screen, the patient may still feel that the doctor is looking elsewhere. This can cause patients to feel more disconnected compared to face-to-face communication. Doctors have to be aware of the potential eye contact issue so as to configure their devices properly and keep an appropriate distance from the screen during the video consultation. However, current video conferencing products do not support camera angle calibration or provide visual hints, which might lead to an unfavorable doctor appointment experience.

Second, patients could be less active in a video-based doctor appointment. Previous research shows that doctors tend to be more dominant during video consultations; they might want to solve patients' problems within a limited time and leave patients less time to express their thoughts (Street, Wheeler and McCaughan, 2000). This could cause patients to feel less involved and less satisfied with consultations. Doctors may not be able to realize their dominant behaviors regardless of being in video or face-to-face consultations. Yet, there is a lack of tools to inform doctors they may have spent too much sharing instead of listening to patients.

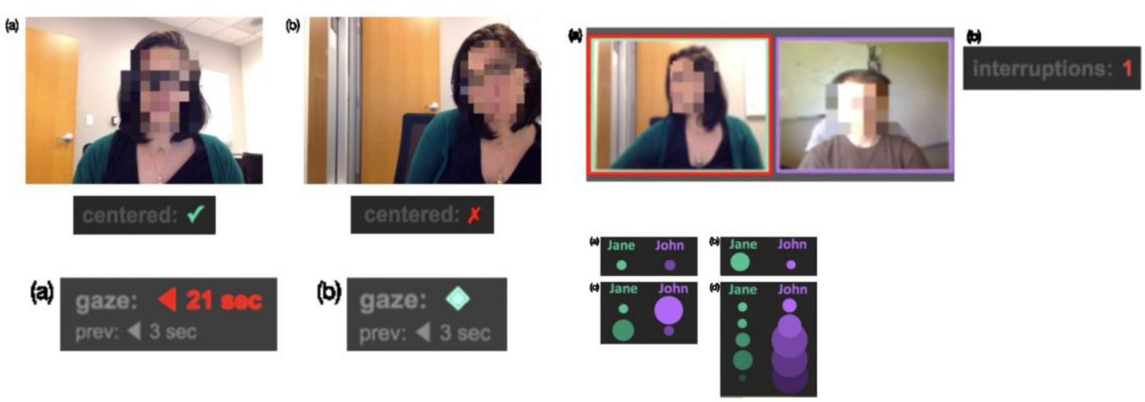

Figure 2.5 A system to monitor gaze and doctor-patient communication (Faucett, Lee and Carter, 2017)

The necessity of making eye contact, showing body gestures, and preventing dominant talking raises the need to remind doctors to adjust their behaviors during video consultations. Current video conferencing products for doctor appointments do not yet support such features to understand doctors' behaviors. Researchers have attempted to build prototypes to analyze doctors' verbal and non-verbal behaviors during consultations, and provide feedback to improve their communication behaviors (Hartzler *et al.*, 2014; Faucett, Lee and Carter, 2017). For example, ReflectLive (Figure 2.5) is a system to provide real-time feedback to physicians on their non-verbal communication behaviors during video consultations with patients (Faucett, Lee and Carter, 2017). The system can sense a group of signs, including speaking contribution, gaze orientation, conversation interruptions, and centeredness on screen. 'Speaking contribution' means the user's speaking time that the circle grows when the user talks. 'Gaze orientation' monitors if the doctor is looking at the center of the screen. 'Conversation interruption' detects the doctor's interruption behaviors when the patient is talking. 'Centeredness on screen' tracks if the doctor's face is in the middle of the screen. Generally, participants feel the system is helpful to remind them to have good communication behaviors with patients during a video conference. However, they also believe that consultation is a complex process, which cannot be simply quantified with a few aspects (Faucett, Lee and Carter, 2017). There are varying patterns for different types of consultations. They may need to read and write notes during consultations, which could lose gaze contact or centeredness on-screen; sometimes, they may have to interrupt patients to break their negative thoughts (Faucett, Lee and Carter, 2017).

The design of video systems would have to consider a range of variables in a doctor consultation, such as different phases (e.g., opening, examination, treatment, close) (Aggarwal *et al.*, 2016), and contexts (e.g., mental health issues, chronic illness). Doctors may need to react differently according to specific scenarios, for example, checking patients' records, or providing more verbal instructions. Yet, systems could not recognize these variables. Thus, it might be more appropriate for a video system to be informative rather than instructional. It means the system could let doctors be aware of their current behaviors, e.g., if they are looking at their patients, rather than regulate what doctors should do, e.g., generating scores to evaluate doctors' behaviors.

Existing Video Doctor Appointment Applications

Figure 2.6 Telus Babylon, with a symptom checker feature

Video conferencing might change the way of how patients look for medical services. In face-to-face encounters, patients who have their own family doctors usually see the same doctors for health issues, unless they are using forms of urgent care or ‘walk-in clinics’. In contrast, patients are allowed to see any doctors online with many video consultation apps. Seeing different doctors could lose continuity of care, which is one of the fundamental aspects of family medicine that doctors can track patients’ health conditions and manage their health records in the long term (Shaw *et al.*, 2018). Applications including Babylon, Medeo, or Doctor on Demand allow patients to see their own records, though; doctors are not authorized to see patients’ previous records when seeing other doctors. Thus, it raises the need for patients who need long-term healthcare to use video consultation applications supporting seeing the same doctor.

Further, pre-established doctor-patient relationships are more welcomed by doctors as it could be challenging to build doctor-patient relationships over video compared with face-to-face visits (Graves and Doucet, 2016; Tates *et al.*, 2017). It brings a new challenge of how patients can trust new doctors each time in addition to using verbal and non-verbal communication techniques. A study explores how patients make use of ‘online ask the doctor’ services (Ding *et al.*, 2020). Patients can use the application to consult with any doctors on the list using text messages or photos for a variety of situations ranging from coughing to cancer. They select doctors based on a few criteria, such as the ranking of institutions where they work, patient reviews, doctors' age, or their communication style. These criteria could be treated as extra information to construct doctors' authority and help patients build trust in doctors.

It is also necessary for patients to know what medical situations can be treated over video. Otherwise, the time could be wasted and patients have to schedule face-to-face visits instead. There have been explorations of automatic systems to assess if patients need to consult doctors (Mairittha, Okita and Inoue, 2018). They are aimed at saving the labor force and avoiding repetitive work. Pre-consultation QA agents ask predefined questions in the form of dialogue. They can continue asking follow-up questions according to patients' yes or no answers. Babylon supports similar features, where Symptom Checker (Figure 2.6) was created to guide patients to possible actions based on their symptoms, e.g., whether they need to consult a doctor or not; or need emergency care. However, the symptom checker feature is independent of doctor appointment services. It does not store patients' choices of symptoms and sends them to the doctor they are going to consult. Patients would have to take extra time to repeat their symptoms to the doctor another time. This time could be saved for expressing other concerns.

Protecting Patient Privacy

Privacy in the healthcare field generally means the protection of patients' health information. Patients have the right to keep the discussion of their health conditions confidential between themselves and their healthcare providers. Privacy in the communication field also involves social and psychological perspectives in addition to information access and confidentiality (Ong *et al.*, 1995; Palen and Dourish, 2003). In a video-mediated consultation, doctor-patient communication takes place in a media space through video and audio channels instead of face-to-face in an exam room. It could affect how doctors and patients exchange information about patients' medical situations, and patients' awareness of if their health information is accessed by others.

Unintended Contact with Doctors

Before having a face-to-face consultation, patients need to make phone calls to a clinic and book an appointment with office assistants. Doctors' availability can be treated as being controlled by their assistants. The use of information technology could change the process. In some cases, patients still need to contact coordinators and see the doctor using a controlled system (Johansson, Lindberg and Söderberg, 2014). However, if patients can make contact with doctors directly through technology, doctors' privacy concerning availability could be violated.

Asynchronous communication tools have been applied as a complement to general face-to-face doctor appointments, by which patients can send text messages to doctors on specialized platforms for medication, appointments, advice, or emotional support (Sun *et al.*, 2013; Eschler *et al.*, 2015). A potential limitation of asynchronous messaging is that doctor-patient communication could be fragmented. Doctors may not be able to reply to patients in time when they are off duty. This could lead to patients' dissatisfaction with both doctors and the system (Sun *et al.*, 2013). However, if doctors' private contact information is given, their life-work boundaries could be violated. It is possible that patients send text messages to doctors when they are busy seeing other patients or they have gotten off work (Ding *et al.*, 2019). Previous studies show that some doctors use Skype to see their patients over video (Armfield, Bradford and Bradford, 2015; Shaw *et al.*, 2018). Patients are likely to make contact with doctors using Skype messages or video calls without appointments. Therefore, video conferencing software like Skype may lack proper control abilities and not be good candidates for doctor appointments. In comparison, video consultation applications like Babylon, Vsee, or Doctor on Demand only allow doctors to initiate video calls to patients. This will enable doctors to handle appointments as scheduled.

Identity Boundary

Doctors are ethically and legally obliged to keep patients' health information confidential and not reveal the information to other people without patients' consent. This is one of the vital principles of building trustworthy doctor-patient relationships (Ong *et al.*, 1995). Patients should not need to worry about their health conditions being exposed by doctors intentionally to anyone else. Even still, patients may withhold some information from doctors on account of social concerns. Previous research shows that patients may not be comfortable disclosing information related to mental health issues or sexually related issues when seeing a doctor face-to-face (Miller, 2003). This could be because these situations are more associated with their identities (Miller, 2003). Patients might treat medical inquiries concerning their personal information as a violation of social boundaries. Thus, doctors are suggested to maintain proper social privacy boundaries in communication with patients by unlinking individual identities with health conditions (Ong *et al.*, 1995).

Previous research also reveals that patients tend to feel less inhibited from talking about stigmatized situations over video (Miller, 2003). This indicates the distancing effect could be beneficial for medical conditions that patients feel overly associated with personal identities and are reluctant to discuss. Techniques that can increase depersonalization might be used in video consultations to encourage patients faced with such situations to share more information. For example, seeing oneself in video communication can improve one's self-awareness and strengthen the attention to anxiety and other negative self-feelings (Miller *et al.*, 2017). Current video conferencing systems all allow patients to turn off their cameras. Nevertheless, they might need to negotiate with doctors about whether their doctors would feel comfortable with not seeing patients during video consultations.

Data Access by Third Parties

A face-to-face doctor appointment generally happens in an exam room where only the patient and the doctor are present. The patient can make sure that there is no one else overhearing at least in that physical space. Likewise, the doctor can have control over who can be present in the exam room. Yet, the situation could change in a video-based doctor appointment. The surrounding environment where the patient and doctor are located could become unclear. A lack of awareness of the context could cause conversations to be overheard by irrelevant people (O'Hara, Black and Lipson, 2006). It could be unknown to both the doctor and patient if there is anyone else possibly involved in the conversation. In the practice of video conferencing for mental health consultations, doctors are suggested to stay in a private room and pan the camera to show their surrounding environments to patients at the beginning of consultations (Shore, 2013). The goal is to create a private setting and reassure patients that they can share personal information without worrying about being overheard.

2.2. Video Communication

I now step back and provide related research on video communication in general, as many topics are relevant to my thesis's specific focus on video calls for doctor appointments. Video communication is widely used in the workplace (Harrison, 2009; Domova, Vartiainen and Englund, 2014; Rae *et al.*, 2015) or by family members, friends or couples in everyday life to share daily experiences (Judge *et al.*, 2011; Brubaker, Venolia and Tang, 2012; Pan *et al.*, 2017). Activities using video conferencing could involve various contexts, such as presenting work, brainstorming ideas, playing collaborative games, or seeing family members. Research shows that these different contexts could raise both similar and divergent design needs. For example, users could desire engagement during video conferencing across all contexts; brainstorming ideas might emphasize the design needs of sharing notes, while playing collaborative games might focus on the design needs of presenting players' body gestures. The use of video conferencing is also socially negotiated, which involves such as awareness, presence, or privacy (Stults, Harrison and Harper, 2009).

2.2.1. Virtual Presence

Presence is the state of being existent or present in a place. It relates to awareness, representation, and context. Awareness can be defined as "a general sense of an individual's whereabouts and activities" (Neustaedter, Elliot and Greenberg, 2006). Whereabouts means a context where an individual is located in, for example, a workplace, home, or public place. One represents themselves as different social characters in various activities, for example, collaborating with colleagues, or sharing life experiences with family or friends. In a face-to-face setting, communication is within a shared physical space, where individuals can have an awareness of the context easily; for instance, where they are and who is around. They are also fully aware of how they interact with others. In contrast, video conferencing can make the communication and interactions different, or challenging, in which individuals have to present and behave in virtually connected spaces.

Awareness of the Context

Video conferencing can give rise to a lack of awareness of context. In other words, people would not know who is around or what is happening if they were not physically there. Therefore, they would not be sure if it is appropriate to initiate a video conversation. This challenge can be found in the context of the workplace or home. In a workplace when it is in-person, one individual may drop by someone's office and be aware of if the colleague they want to talk to is available by knocking on the door, seeing through the window, or looking at a ‘do not disturb’ sign hung on the door (Bellotti and Sellen, 1993; Boyle, Neustaedter and Greenberg, 2009; Henderson, 2009). It is easy to know the colleague’s availability, for example, if they are in the office or with someone, or if there is a sign on the door. Yet, the context could be unknown if an individual is not physically there. Directly initiating a video call can be considered obtrusive without knowing their availability first (O’Hara, Black and Lipson, 2006; Judge and Neustaedter, 2010). Thus, people generally would confirm availability first or have scheduled time before initiating a video call. Such conditions can similarly happen in family communication as well. Video conferencing acts as a bridge to connect intimate family members living over distance by seeing each other, sharing life experiences, or participating in activities together (Judge, Neustaedter and Kurtz, 2010; Kirk, Sellen and Cao, 2010). A video call can be initiated with another form of confirmation first (e.g., a text message, or email). Alternatively, people may spontaneously have an audio call rather or semi-scheduled (e.g., they have shaped a life pattern to call at a rough time), then turn to a video call (Ames *et al.*, 2010; Kirk, Sellen and Cao, 2010). In general, confirming one’s availability over distance could take a bit more effort than when in person.

Although a variety of strategies have been designed to support awareness in video-mediated communication, separate issues still exist. For example, the design of ‘availability status’ (e.g., online, busy, away) imitating the ‘do not disturb’ door sign can convey availability information (Judge and Neustaedter, 2010). However, it could become meaningless if users merely log on to the video conferencing system when they need to have a video call (Judge and Neustaedter, 2010). Thus, the design may not work exactly as what designers intend it to.

Conveying Information

Video conferencing can result in the attenuation of conveying information as effectively as in a face-to-face setting. Individuals in the presence of others convey information through verbal and non-verbal languages, such as facial expressions, speech, positions, postures, and gaze (Bellotti and Sellen, 1993). Presenting oneself over video is not the same as in face-to-face settings on account of the following aspects.

First, an ordinary video call generally presents an individual's visual in a limited size (e.g., a desktop display, or a phone display). Thus, visuals of their body could shrink a lot or could be cropped, leaving only a part of their body in the frame. People at the other end may not be able to see facial expressions clearly or body language, such as body gestures lower than one's shoulders (Bellotti and Sellen, 1993; Nguyen and Canny, 2009; Kirk, Sellen and Cao, 2010). This could be more salient in video chats using mobile phones because people usually hold the phone a short distance from their face, and the limited field of view causes only their heads and shoulders to be seen. Yet, body language plays an essential role in human communication to convey empathy and trust, and build interpersonal relationships (Nguyen and Canny, 2009). Moreover, it does not mean the larger, the better. Exaggerating one's presence to be larger than the life size could make users feel uncomfortable as it could draw too much attention (Brubaker, Venolia and Tang, 2012). The limitation of a narrow field of view issue becomes significant in communication involving a group of people, for example, a family video chat (Ames *et al.*, 2010). Family members have to squeeze themselves into a small physical space to have them be presented at the other end (Ames *et al.*, 2010). This could limit their ability to share other activities other than talking to each other.

Figure 2.7 Coordination between the local and remote user when showing the camera view (Jones et al., 2015)

Second, video conference users could face challenges in controlling their presence, such as mobility and changing volumes. Mobility relates to how individuals can move freely in a context. The ability could be lost in video-mediated communication. And the control is handed over to users at the other end. If the camera is mounted, for example, on a desktop monitor or a wall, a user would only be able to see a fixed camera view. This would require careful configurations in a group meeting to see everyone in the meeting room (Henderson, 2009). Turning the head to a particular direction when talking to someone could become challenging if lacking mobility in a video-mediated meeting (Henderson, 2009).   Mobility is welcomed in domestic communication as well. Family members share home activities by positioning the camera to different locations or orienting to different angles (Ames *et al.*, 2010; Kirk, Sellen and Cao, 2010). However, people at the other end have no control over which directions or locations they want to see; they have to negotiate with local users to get the desired camera view (Figure 2.7) (Jones *et al.*, 2015; Baishya and Neustaedter, 2017; Neustaedter *et al.*, 2020). Similarly, people have no control over their acoustic presence at the other end. They can not be sure if their voice is heard, if the voice is muted, or if the volume is too high or too low (Bellotti and Sellen, 1993; Judge, Neustaedter and Kurtz, 2010).

Third, video feedback of seeing oneself from their own camera could lead to divergent consequences. Seeing oneself in a video chat is a predominant interface design feature to provide feedback on how one is presented via the camera (Miller *et al.*, 2017). However, some people may easily forget to stay in the video frame all the time (Ames *et al.*, 2010).   Previous research shows that visual feedback can increase self-awareness (Miller *et al.*, 2017). Self-awareness could be beneficial or harmful in different contexts (Miller *et al.*, 2017). Self-awareness could help users have better control over their social behaviors and facilitate positive communication. However, self-awareness could be detrimental as patients with mental health issues could generate a sense of anxiety due to an increase in self-awareness (Miller *et al.*, 2017). Hence, the design of video feedback faces challenges when designing for different populations and contexts.

2.2.2. Conducting Collaborative Activities

Showing People, Objects, and Activities

Video conferencing makes it challenging to show people, objects, and activities. In the workplace context, an everyday collaborative activity could be having a meeting in a room, where a coworker over distance may want to share documents, whiteboards, screens, or other objects in their office (Henderson, 2009). The colleague can distribute documents readily by walking around the room when it is in person. In contrast, it could be challenging over video as physical objects are not able to be delivered virtually. This may require everyone to have a device to receive electronic documents if they hope to look through freely, unlike a presentation where everyone can focus on a single page. Sharing different objects in the remote office could require a camera with mobility, which can be positioned to capture various locations and oriented to random directions. One could imagine doing these activities using a mobile phone as it is highly portable and has been widely applied in everyday life (Jones *et al.*, 2015; Rae *et al.*, 2015). However, sharing objects in a meeting context could require the camera to be both mobile and stationary. A presenter has to hold the phone all the time. It could be inconvenient for the presenter to switch among these activities, for example, moving the camera to a particular position and showing a whiteboard a couple of feet away.

Camera work is the continual reorienting of a mobile phone's camera in order to capture a view that is sufficient for remote parties to know what is happening (Jones *et al.*, 2015; Neustaedter *et al.*, 2015). It could be uneasy for people to coordinate camera work when showing objects or surrounding environments using a mobile phone (O'Hara, Black and Lipson, 2006). First, switching between the rear and front cameras of the phone could not be comfortable enough and sometimes tiresome (O'Hara, Black and Lipson, 2006). Therefore, people may not bother to switch the camera and just rotate the camera manually (O'Hara, Black and Lipson, 2006). The problem could be that they might not be able to see what is captured in video frames if solely using the front camera to show around the space or capture some objects. Similarly, their face could not be seen if solely using the back camera.

Figure 2.8 Sharing outdoor biking activity (Neustaedter *et al.*, 2020).

Second, it might yield poor audio quality if the phone is set away from the speaker (O'Hara, Black and Lipson, 2006). The issue could happen not only with a mobile phone, but also with other video conferencing devices. Designs of these systems might not assume such scenarios of showing things. Similar situations could happen in the home context as well. Family members may share a variety of life experiences in different home locations. For example, they share cooking or eating activities in the kitchen (Judge *et al.*, 2011); grandparents see their grandchildren playing in the living room (Judge and Neustaedter, 2010); or they may even share outdoor activities (Figure 2.8) (Neustaedter *et al.*, 2020). A laptop's camera tends to involve more family members in the frame than a mobile phone, but users usually do not move the laptop during the video call as it is less mobile than a phone (Ames *et al.*, 2010). This could constrain the capability of sharing other activities across different locations in the home. Further, activities like instructing family members to cook over video (Brubaker, Venolia and Tang, 2012) could require high mobility, as found with a phone. Yet, holding a phone during cooking would not be an enjoyable experience. These rich scenarios would also need the design of camera work to be flexible, like that in the workplace context, so as to adapt to different life activities.

Interacting with Remote People

The topic of showing things described previously is about mobility in a presenter's local space, whereas remotely interacting is about the mobility of a local collaborator in the remote space. Interaction behaviors in a face-to-face setting could involve looking at someone during a talk, physically touching objects during a task, and presenting body gestures to convey instructions (Henderson, 2009; Neustaedter *et al.*, 2020). These behaviors could become challenging in a video-based collaborative activity.

First, the local user cannot freely turn their 'remote head', a display, to different directions (Henderson, 2009); or, they do not need to. A desktop display or a phone display does not support rotation. The feature could be helpful in a group meeting where people are sitting around, so some of them may not be able to see the screen (Henderson, 2009). Otherwise, the display has to be positioned at the end of a room where the presentation is given. Further, frames of the remote meeting room are generally shown on a limited-size display such that the local user does not have to turn their head to see someone particularly. This could also confuse remote participants whom the local user is talking to, if not referring to them by name.

Figure 2.9 An example of giving instructions with one's finger which the remote person cannot see (Jones *et al.*, 2015).

Second, physical body interactions cannot be applied in an ordinary video chat. People are not able to indicate precise positions or directions over video as in a face-to-face setting by pointing directly with fingers (Sodhi, Benko and Wilson, 2012; Gauglitz *et al.*, 2014). Remote collaborators could solely use verbal instructions to tell what local collaborators need to do. Sometimes, remote collaborators unconsciously point their fingers at their screens without realizing local collaborators cannot see them (Figure 2.9) (Jones *et al.*, 2015). Further, local collaborators may not perform body gestures effectively and efficiently when imitating remote collaborators' gestures due to a lack of visual or haptic feedback (Tang *et al.*, 2015).

2.2.3. Privacy Aspects in Video Communication

Privacy is always entangled in communication and interactions. Privacy can involve diverse concepts as it is highly associated with contexts; it can be interpreted in varying ways by researchers from different fields (Boyle, Neustaedter and Greenberg, 2009). For example, privacy can be articulated as people disclosing their personal information selectively; they can keep an appropriate amount of space from others (Palen and Dourish, 2003). The concept of space from a broad sense could be either a physical space or a virtual space, for example, psychological distance (Palen and

Dourish, 2003). It also relates to whether people feel comfortable communicating and interacting with others.

Privacy Boundary Theory

Privacy is treated as a "dialectic and dynamic boundary regulation process" (Palen and Dourish, 2003). The dialectic process refers to the fact that privacy is not determined by fixed rules but is conditioned by different contexts and people's intentions. For example, one might feel comfortable talking about life experiences with family members, but the same conversation might feel intrusive with a stranger. The dynamic process refers to the idea that a boundary exists between privacy and non-privacy, which can shift according to different circumstances. The essence of privacy is about boundary management, including disclosure boundary, identity boundary, and temporal boundary (Palen and Dourish, 2003).

The disclosure boundary means privacy is not about retaining all the information within ourselves. Instead, people disclose some personal information to keep daily interactions with others (Palen and Dourish, 2003). People may reveal their presence in the office to inform the availability and facilitate collaboration with colleagues (Bellotti and Sellen, 1993; Henderson, 2009); they may share daily activities with family members to build up emotional bonds (Judge *et al.*, 2011; Pan *et al.*, 2017).

The identity boundary means that one acts in society as a representative of one or multiple social groups (Palen and Dourish, 2003). There exist social norms in terms of how they interact in face-to-face settings. People's physical appearance and behaviors could represent their social characters, for instance, as colleagues or families. Nevertheless, the representation of oneself in the virtual network world could become vague and different (Palen and Dourish, 2003). This could affect how one is known by others.

The temporality boundary means communication and interactions happen in a temporal sequence (Palen and Dourish, 2003). Privacy management in the physical world can be manageable because people can actively control the disclosure of information from the past or present, thus, affecting the privacy boundary at present or in the future. However, the mediation of technology can make information permanent in a negative way, such as being accessed by irrelevant people. For example, there could be privacy risks when patients' medical records are stored electronically which might be accessed other from their healthcare providers without being noticed (Perera *et al.*, 2011).

Privacy with Availability

One social norm of human interactions is that people intend not to disturb others when they are unavailable. There are different ways to know an individual's availability in the physical space, for example, by seeing a 'do not disturb' sign on the door, or observing the individual's facial expressions, behaviors or activities (Boyle, Neustaedter and Greenberg, 2009), people could be aware that it is not a good time to interrupt. Yet, such hints could become unknown when people want to initiate video calls with others. This is termed a 'lack of control over recipient context' (O'Hara, Black and Lipson, 2006) from the caller's perspective. From the recipient's perspective, it would be a violation of solitude, the state of unwillingness to interact. The call recipient chooses not to answer the call, defer it, or switch to an audio call instead (O'Hara, Black and Lipson, 2006). Always-on video systems allow colleagues or family members to see each other and communicate over long durations of time (Henderson, 2009; Judge, Neustaedter and Kurtz, 2010). The state of solitude could be easier broken as people at the other end could see through the camera all the time. Once individuals appear in the video frame, they might be called by people from the other side.

Privacy with Confidentiality

Video conferencing is thought to present more visual information than text messages or audio calls. However, too much visual information could lead to privacy concerns over sharing more than one intends to. The information considered private could be one's surrounding background or social contexts. An individual may not want to share their bedroom background or casual dress in a video conversation with colleagues (O'Hara, Black and Lipson, 2006). Similarly, people may want to hide their locations or lifestyles as well; yet, the visual channel makes it difficult to hide in comparison with audio only (O'Hara, Black and Lipson, 2006). Further, even very close relationships, such as family or romantic relationships, could also raise confidentiality concerns. They might feel it is not necessary to hide backgrounds or lifestyles intentionally. However, long-term, always-on visual exposure could be intrusive, even if a camera is oriented towards a public space in the home (Judge *et al.*, 2011). Software-level configurations like muting audio or blocking video frames may not be fully adopted or trusted by family users. They may choose to orient the camera towards a wall or cover the device in order to keep confidentiality (Judge *et al.*, 2011). There exist design challenges in how to build users' confidence in protecting visual and acoustic information from being disclosed.

Privacy with Control

Video chats in a public area could make callers, takers, and surrounding people lose control over their autonomy. Autonomy is "the freedom to choose how one acts and interacts" within the environment (Boyle, Neustaedter and Greenberg, 2009). Video conferencing connects multiple physical spaces that could have varying social contexts. It is easy to involve irrelevant people from either the caller's side or the recipient's side and present them in the video call. Visuals or voices from the other end could be seen and heard by surrounding local people, no matter whether they intend to or not (O'Hara, Black and Lipson, 2006). These surrounding co-presenters may not want to be involved in the video call (O'Hara, Black and Lipson, 2006; Neustaedter *et al.*, 2020).

Bellotti and Sellen identify control as a design principle to protect privacy (Bellotti and Sellen, 1993), meaning people can control what information can be captured, who can have access to their information, and how the information can be used. For example, if a system fails to indicate to people alongside the system that a camera is on, they could be watched without acknowledgment, or they might do something private such as changing clothes (Henderson, 2009; Judge, Neustaedter and Kurtz, 2010; Brubaker, Venolia and Tang, 2012). This differs from reciprocal conversations in person where 'if I can see you, you can see me.' Video conferencing can make the visual solely one-way.

2.3. Summary

This chapter presented a literature review on video-mediated communication and telehealthcare. I described how telecommunication technologies could distribute healthcare services, including conducting physical exams and visually inspecting patients' situations. I introduced aspects of doctor-patient communication, including patients' and doctors' different perceptions of healthcare, relationship building over distance, as well as privacy protection. I also presented current commercial systems used to provide patients with healthcare services and a design gap of prior research and existing applications in supporting video doctor appointments from home settings. Then, I presented related research on video communication in the context of workplace and home life, as they may share similarities with my focus on video calls for doctor appointments. It includes virtual presence relating to awareness, representation, and context; collaborative activities that involve showing and interacting with people and the environment; and privacy in terms of availability, confidentiality, and control. This work establishes my research on exploring video-based doctor appointments in home settings. As can be seen, the related research does not contain a deep understanding of needs from both technical and socio-technical perspectives for home-based doctor appointments for general medical situations.

In the following three chapters, I present three studies that investigate the needs of patients and doctors in the virtual appointment context, design factors of video systems, and how these factors support patients seeing doctors over video.

Chapter 3.

A Scenario-based Study of Doctors and Patients on Video Conferencing Appointments from Home

This chapter presents an exploratory study that investigates the needs of doctors and patients for video conferencing to support doctor appointments with a range of medical situations. The chapter includes a detailed description of the participants recruitment, method, data collection, and findings. I used a scenario-based interview method where participants were shown pre-recorded scenarios of mock app-based video appointments covering various common conditions and were interviewed about the scenarios. The study explored the following research questions:

1) What appointment types would be appropriate for smartphone app-based video calls from home?

2) What challenges and concerns would doctors and patients have with the design and interaction needed for such video-based appointments?

The study informs the interaction and socially related challenges in the use of existing video conferencing systems for doctor appointments and helps to guide my further design work on the video doctor appointment prototype.

3.1. Participants

I recruited a total of thirty-three participants into this study, including twelve family physicians (seven females, five males) and twenty-one patient participants (sixteen females, five males) who had visited doctors. The gender imbalance was unintentional and based solely on who responded to our participant call and was willing to participate. Recruitment methods included posting advertisements in clinics, on local doctor community newsletters, on university mailing lists, social networks (e.g., Facebook, Twitter), and snowball sampling. Participants resided in the Metro Vancouver area in British Columbia, Canada. The doctor participants were within the age range of 31-58 (*M*=41.92, *SD*=9.34), with years of practice from 2-32 (*M*=13.00, *SD*=10.43). Patient participants were within the age range of 19-71 (*M*=36.73, *SD*=15.57).

All general practitioners saw patients for a range of health concerns, as opposed to specialist appointments. Four doctor participants used video conferencing with their patients, and five of them used telephone appointments some of the times. I included doctors who already used video appointments with some of their patients, doctors who had the intention to use video appointments at some point in the future, and doctors who were generally opposed to video appointments. This was so that I could get a broad perspective on the technology. Six of our patient participants visited doctors regularly for long-term disease control, such as high blood pressure, gout, anxiety, arthritis, depression and digestive issues, and the rest for occasional situations when sick. None of the patient participants had experience with doctor video appointments; I was not restrictive on this regard, given that our goal was to assess perceptions of different types of appointments, as opposed to prior experiences with video appointments. Patient participants had a range of occupations, including student, salesman, researcher, designer, administrative, clinic and pharmacy staff, etc., and ethnic backgrounds including European, Asian and Middle Eastern descent. Again, I wanted to explore a broad range of perspectives on the topic, which is consistent with the recruitment of our doctor participants.

3.2. Method

Semi-structured and scenario-based interviews were conducted to acquire an in-depth understanding of doctors' and patients' previous experiences and their perceptions about video-based appointments. Participants participated from a location that was convenient for them, or one that they were comfortable participating from. Table 3.1 listed the number of doctor or patient participants who attended in person or over video.

Table 3.1 Interview Approaches with Participants

	In person	Over video
Doctor participants	9	3
Patient participants	17	4

Each interview session lasted between 50 and 90 minutes. The interview contained two parts. In the first section, participants were asked about appointment experiences in-person, over telephone or video. In the second section, six video scenarios depicting varying video-based appointments were shown to participants to inquire about their reactions. I detail each section next.

3.2.1. Interviews on Previous Experiences with In-Person and Video-Based Appointments

A total of nine doctor participants had used phone or video appointments in the past. They were asked about what medical situations they handled using these technologies. Then we asked these doctor participants about patients' demographics and reasons for using phone or video for appointments. We also asked if there were situations that were eligible for phone or video visits, but the technology was not used and why. For doctor or patient participants who had not used video appointments, we asked whether and why they would be interested in using the technology or not. We grounded the questions in specific appointments rather than general opinions to obtain detailed data. That is, we had participants describe specific past appointments where they could comment on the use of video or how it may have been applicable. For example, we asked, "Which appointments do you think are (not) eligible for video visits?", "How did you (the patient) describe the situation to the doctor (you)?", "How was the patient (were you) examined?" The goal was to understand what benefits and challenges video conferencing technology could bring to the appointments if used and how systems would need to be designed to support the appointments, if done over a video call. This section lasted around twenty minutes.

3.2.2. Scenario-Based Interview Preparation and Planning

Next, a scenario-based interview was conducted to learn how participants would react to video-based appointments with varying medical situations. I decided to show participants pre-recorded scripted videos to discuss video conferencing usage for certain situations that participants may not have experienced or those that might not exist yet in current practice. I utilized this scenario-based methodology not to infringe on participants' privacy, as some topics that I wanted to explore were private or sensitive in nature. The method resembled scenario-based design (Erickson, 1995; Carroll, 2000) which is usually applied in early design phases where people and design artifacts are presented in videos as a conversation piece to explore future technology usage.

Previous research has taken a similar approach, by providing vignettes of video appointment patients for doctors to diagnose (Jiwa and Meng, 2013). In our research, we provided doctor and patient participants with role-played videos (as opposed to vignettes) and asked for their thoughts on partaking in such types of appointments. Thus, we illustrated to participants what various scenarios could actually look like during video-based appointments, including aspects such as the environment (e.g., calling from home with others around or not), people's facial expressions, body language, how they used mobile devices to communicate or do examinations, and obtain feedback on perceptions of video-based appointment for such medical concerns.

Alternative study methods might include exploring video visits in person or role-playing different scenarios as opposed to presenting them with pre-recorded videos. However, there could be critical ethical challenges. First, observing actual appointments could be extremely intrusive for patients if appointments are about sensitive topics such as drug usage, domestic abuse, or private body parts. Second, role-playing such scenarios could be awkward and intrusive as well. In contrast, pre-recorded videos would avoid risking participants' privacy. It also allowed to gauge all participants' reactions to the same situations as they all watched the same video clips. Lastly, we were able to explore multiple scenarios with each participant rather than a subset of them, which might be the case if participants were observed in an actual appointment about a single ailment.

Thus, six sample scenarios were designed and recorded prior to conducting the study, where a patient used a mobile phone from a home setting to video call a doctor. We first brainstormed a large list of appointments and speculated the potential benefits and challenges involved. Next, a set of six scenarios were selected to ensure that a range of situations could be represented. These scenarios were reviewed by a doctor who was not a participant in the study. We then iterated the storyboards for each scenario. Our six scenarios were chosen based on the following criteria. First, we wanted common medical inspection methods (Wirtz, Cribb and Barber, 2006; Pawlikowska *et al.*, 2007) to be covered in the scenarios, including inquiry, observation, and palpation (touching the body during an exam). Second, we wanted a variety of camera work to be presented in the videos, e.g., capturing different body parts by orienting the camera to different directions. Third, we wanted the scenarios to cover topics with potential privacy concerns at varying levels. Several scenarios contained no privacy concerns, such as seeing a doctor for a common cold, while others could be sensitive in terms of conversation or what would be shown on camera. While the resulting scenarios are not a representative sample of patient appointment types across the medical literature, they provide a sample of situations that help to push the envelope of remote doctor-patient appointments. The resulting scenarios are briefly described as follows (using a female doctor and a female patient):

1) ***Cold***: The patient has a cold and sore throat. During the video call, the patient explains her symptoms, and the doctor asks the patient to hold the phone up so the doctor can see in her mouth. The doctor asks the patient to shift the camera to an appropriate angle and say ‘Ahhh’ to expose the tonsils. The patient follows the directions.

2) ***Fell while jogging***: The patient fell down while jogging, which hurt her knee and abdomen. During the appointment, when showing the doctor her knees, she switches to using the back camera. Then, the doctor asks the patient to lift up her shirt to uncover her abdomen. The patient switches the phone back to using the front camera. She holds the phone in one hand and follows the doctor’s instructions to press on different areas of her abdomen with her other hand.

3) ***Sleeplessness***: The patient has been struggling with stress at work and sleeplessness. As part of the appointment, the doctor asks about her lifestyle, alcohol usage, and medication. The patient describes challenges with excessive alcohol consumption.

4) ***Drugs***: The patient’s arm was itchy. In the appointment, the doctor asks the patient about what food and medication she recently had and whether she was exposed to sunlight or something unusual. The patient feels awkward but still honestly tells the doctor that she had smoked cannabis. The doctor prescribes the patient medication.

5) ***Domestic abuse***: The patient experienced domestic abuse, which bruised her arm and forehead. The patient scheduled a video appointment in their home. At the beginning of the appointment, she describes to the doctor that she accidentally fell down and showed her bruises to the doctor. The doctor continues asking for more explanations, and the patient confides that there was partner abuse.

6) ***Private parts***: The patient scheduled a video call for an annual exam follow-up. During the video call, she describes concerns regarding her genital area. The doctor asks to visually examine the area. The patient takes off her clothes and shows her genital area to the doctor with the mobile phone camera. The doctor then asks about the patient’s history.

Each scenario was recorded twice, once with male actors for the patient and doctor, and once with female actresses for the patient and doctor. The patients were filmed in a home setting in our lab and the doctors were in an clinic setting. They all used the same scripts, and any sensitive video clips were blurred for privacy.

Figure 3.1 shows images of the scenarios from both the male and female versions. In each video scenario, participants were shown three clips at the same time. On the left side was a third-person view where participants could have a general understanding of the context on the patient's side. The other two clips were the camera views of the patient and the doctor respectively. Thus, we included the types of camera views that are present in smartphone apps designed specifically to support video appointments, though none show both first-person and third-person views at the same time like we did. This could be considered to be more futuristic. we blurred the patient actor’s partially covered or exposed body parts in the videos to protect their privacy. We blocked the video instead of actually recording the video of the private part viewing in the sixth scenario. Each video was around two minutes.

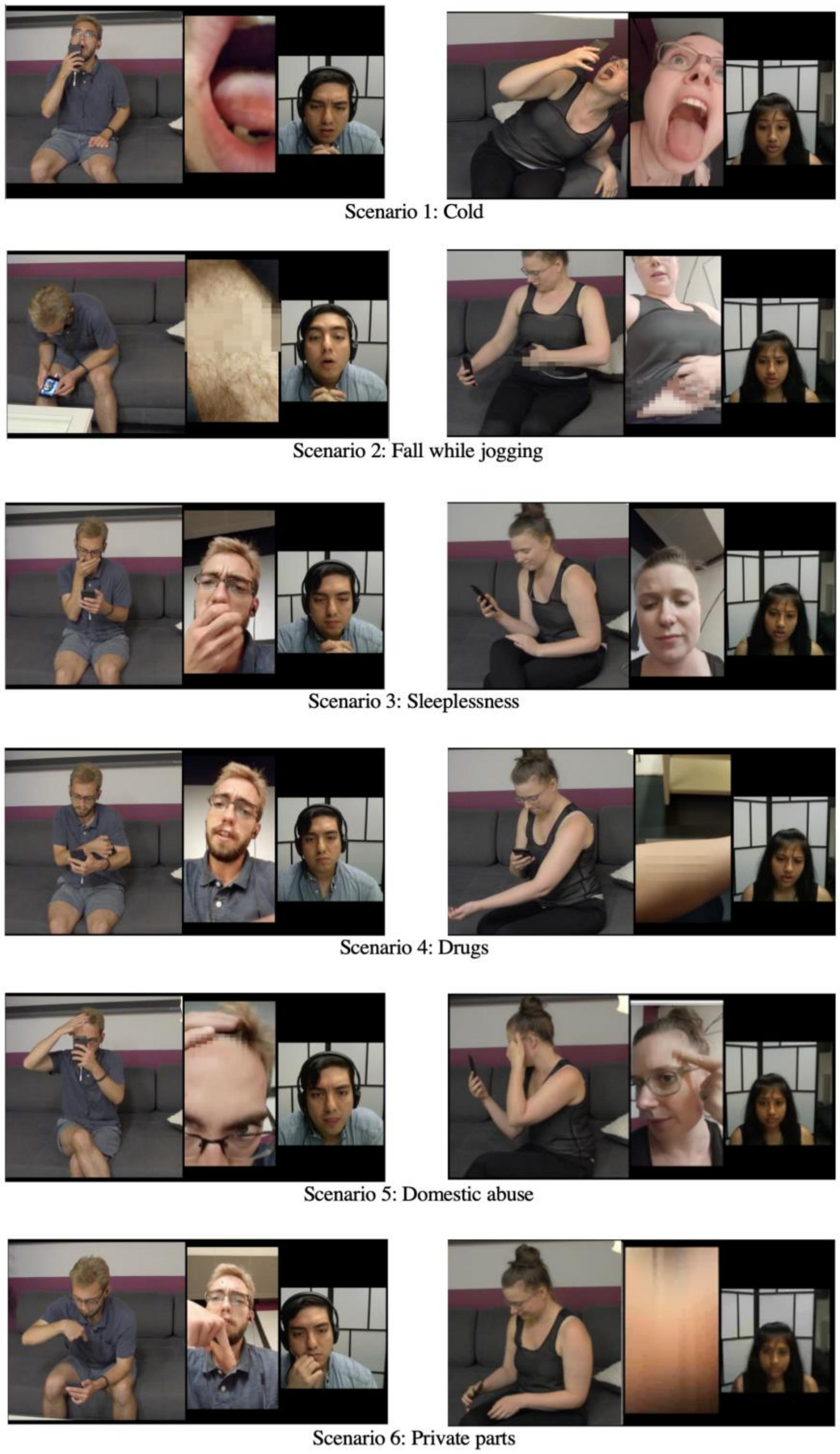

Figure 3.1 Screenshots from video scenarios. Each video depicts a medical situation. There are three views in each video, from left to right: third-person view in the patient's home, camera view of the patient, and camera view of the doctor. (Confidential details have been masked in the image.)

Since none of our participants had ever had a video-based appointment before, the types of video appointments being presented to them were completely new. Our doctor participants with video-appointment experience had only ever done a subset of these appointment types, focused heavily on simple situations which involved slight or no camera work like Scenario 1: *Cold*, Scenario 3: *Sleepless,* and Scenario 4: *Drugs*. Looking across the literature, the studies I am aware of have only ever looked at appointment types generally consistent with what our doctor participants encountered, and little has looked at the detailed types of camera work (including three different camera views) and privacy as I have presented.

3.2.3. Scenario-Based Interview Method

Participants were shown videos one at a time and asked questions based on each scenario after watching each video. Participants chose which video they wanted to watch, either male or female, as I felt that it might promote stronger empathy from participants and help better imagine how they would react to the situations in the videos if they selected their gender of choice. For each video, the interviewer briefly described the situation and then played the sample video-based appointment. I did not counterbalance the ordering of scenario videos as I wanted to gradually increase the potential for privacy risk and show somewhat commonplace situations first. Our work was also intended to be exploratory as opposed to a controlled experiment. This does generate the limitation of possibly biasing how participants felt about the scenarios given their ordering.

Participants were asked after each scenario if they had experienced similar situations in-person or over video and how they felt about these situations being conducted over video conferencing. As examples, we asked “How would you feel if you were the patient in the video?”, and “How would you compare an in-person appointment with that in the video call?” The purpose was to encourage participants to provide more detailed insights on the potential benefits and challenges of using video conferencing in contrast to in-person visits. For example, for Scenario 1 and showing the throat, participants were asked to think about similar cases where patients might need to show other body parts using their mobile phone camera. For example, “Can you think of similar situations where you need to show body parts to your doctor? And how would the video appointment be different from in-person?" For Scenario 3 and the sleepless issue, participants were asked to recall other mental health issues and think about what aspects would be essential during the appointment, and how video conferencing might affect the appointment. In this way, the questions would help me to investigate a larger array of situations. After all of the scenarios were shown and discussed, we asked participants if there were any scenarios that were not covered that they wanted to talk about. The goal was to avoid missing important information. The scenario-based interview lasted about 50 minutes.

3.3. Data Collection and Analysis

We audio-recorded all the interviews with permission from participants. All interview data was fully transcribed. Three researchers were involved in data analysis. The patients' and doctors' data were analyzed independently. The patients' data was coded by the first and second researcher. The doctors' data was coded by the first and third researcher. Open, axial and selective coding methods were used to code the data. For example, open codes such as "video recording" or "malicious patients" were created and represented participants' privacy concerns to particular scenarios conducted over video. Each coder read through and coded transcriptions independently. Then, axial codes were discussed by the coders and merged. Next, these codes were categorized into high-level descriptive themes and corresponding sub-themes after a few rounds of discussion. In this study, I reorganized sub-themes and framed them to represent patients' and doctors' reflections in a comparative way. These four themes included the *accessibility of appointments*, *camera work and examination*, *relationship building* over video, as well as *privacy and control* during video appointments. They are described in the following sections. Doctor participants' quotes are listed as D#, and patient participants' quotes are listed as P#, followed by their gender identity and age.

3.4. Findings

3.4.1. Accessibility of Appointments

Video-based appointments change the way in which people make appointments and see a doctor over distance. They connect doctors and patients in a convenient way without requiring travel. Yet I learned that such appointments also raise concerns related to scheduling and accessibility. In this section, I present patients' and doctors' opinions in relation to the accessibility of appointments.

Saving Time vs. Missing Information

First, patient participants believed that waiting time for an appointment could drop sharply from days or even weeks to within hours or less if video-based appointments were used compared to in-person appointments. This was also found in a previous study that showed physicians were more accessible because of telemedicine systems (Chudner *et al.*, 2019). Patient participants explained that they were often frustrated when they had to spend time in a waiting room for an in-person appointment, even after booking a specific time. Doctors were often 'running behind' and patients said they would often sit in the waiting room performing idle activities. In comparison, they perceived that video-based visits would provide them with a means to reduce waiting time. They could be more flexible with their time while at home and perform other activities while waiting for their appointment. Even if the doctor was running behind, it still meant they could do things that were considered to be productive. For example, participants said they could continue any existing work or do housework while waiting for their appointment and the doctor to video call.

Unlike patients, however, doctors believed that time spent in a waiting room, or transitioning into and out of it, was sometimes valuable. This need has not been described in prior literature. Doctor participants worried about potentially missing some essential information that they might normally see in the waiting room for in-person appointments. This concern was brought up when talking about the *Sleeplessness* scenario, during which doctor participants referred to general neurological and mental health issues with their responses. Our doctor participants suggested that one important facet of an appointment was the ability to identify other aspects that were affecting a patient rather than just what the patient was telling the doctor. They said that their inspection of a patient happened not only in the exam room, but also outside of the appointment in the waiting room. They would often glimpse at how patients looked when waiting, how patients interacted with staff, and how patients walked into the office. This kind of auxiliary information was able to provide doctors with important clues about patients' overall status. They believed that their clinical gestalt, which was built with years of experience, was helpful in providing additional insights. Our doctor participants felt this kind of information could easily be lost over video.

> Like Parkinson's… how long you were to kind of stand up, their gait, a little bit shuffled or you're noticing a little tremor…Sometimes I'll hear them checking in with the front staff and they just seemed a bit more confused or something…So you're seeing kind of this interaction with other people ... –D5, Female, 43

> Walking is important, especially if they have pain, joint pains and things like that, you see how they walk. Some people with neurological issues, you need to see how they walk…if the camera is far away, you may be able to see it. –D2, Male, 31

This suggests design needs for particular populations, for example, individuals with neurological or kinesiological conditions, where designs might provide multiple angles of video or track patients' activity and movements (inside the application and within their environment) to gain additional insight. Yet, such video information could be very challenging to get since a common video consultation usually starts with the call ringing and a patient's face shown on camera and ends with the call hanging up. There is no auxiliary information shown before or after the call. Thus, the types of information that our doctor participants described could be easily missed over a traditional video call. Moreover, this type of information could be challenging for doctors to collect through other means. For example, interactions with other people besides the doctor would be non-existent and not possible to see. A doctor could ask to see a patient's normal movement by placing the camera some distance away from them and then moving around. Such placement could easily be challenging to perform though to ensure the patient is in view; I explore this point further when discussing camera work in subsequent sections.

Ease of Booking Appointments

Second, I learned that, because video-based appointments offer greater accessibility, patients might be motivated to request appointments more often than if they were just available in person. Our patient participants said that they relied on their own judgement to decide whether to visit their doctor when it was an in-person appointment. They assessed the level of severity of their situation based on subjective feelings, past experiences, or medical knowledge, albeit limited. Although they said they would not bother to see a doctor for minor things, for example, a general cold, they reported that a lot of times they were not sure whether they should visit a doctor. Sometimes this decision was aided by web searches for medical information.

> Instead of you waiting for a week to visit the doctor you can use this system to have primary comfort to know how serious or not the problem is until you find an appointment time. -P12, Female, 32

Some patient participants felt that a lower barrier to scheduling an appointment with a doctor over video might make it easier for them to meet about more minor situations where they were unsure as to whether an appointment was necessary. This could have implications for the health and technology communities; more video visits could lead to lowered population illness and disease (as patients do not have to wait until the condition is serious enough for an in-person visit), but current systems may not be able to handle an increase of video-based appointments and their replacement of in-person visits (due to technological and design constraints).

Three out of four doctor participants who already had video-based appointments with patients reported that their patients usually brought up fewer issues during a video visit compared to an in-person one, and it took less time than a general visit in the clinic. The specific reasons were unknown, however, they thought that it could relate to a cost-benefit ratio. That is, patients who had to spend a lot of time getting to the doctor may want to ensure they talked about as much as possible in a single appointment to create large benefits. On the other hand, video appointments were seen as easy to do and requiring less effort. Thus, patients may be okay talking about fewer issues.

> I find patients just tend to be much more direct and they just want whatever they wanted…versus often in person they have a list…or they'll chitchat a bit more. –D7, Female, 44

Doctor participants were concerned that patients may book appointments that were not good candidates for video calls, e.g., those where a diagnosis is hard to give using a camera only such as the *Fell while Jogging* scenario. In these situations, doctors thought that appointments may have to be rescheduled in order to be handled in person. This could waste time.

> I would be frustrated if I'm doing video conference and then realizing, oh geez, this doesn't work because I need to do an exam on you now. –D5, Female, 43

Thus, doctor participants suggested it was important to have appropriate screening mechanisms in place so that a doctor or staff member could determine if the appointment could be video based when it was being booked. However, doctors also commented that staff were often not yet fully aware of what made an appointment appropriate for video versus in-person only. On the other hand, it could be helpful to further equip existing and new telehealth systems with innovative technologies to enable doctors to perform virtual examinations that are not yet possible (e.g., palpitation).

Further, doctor participants pointed out that a patient may see many different doctors, which could raise issues with the continuity of care over time and create challenges for doctors to understand a patient's history. This was also found in (Eschler *et al.*, 2015). Doctor participants all felt that video appointments should be used for ongoing relationships rather than patients who are willing to see any doctor who was presently available.

> If the continuity is disrupted and they're getting prescriptions for conditions and being diagnosed with things that were never even notified, then that becomes a problem in terms of continuity in quality of care … It's harder to take the best care possible to the patient. –D4, Male, 45

> I care about your blood pressure today, but over the whole year, am I actually managing it in a larger sense…It's not fair to family doctors if they're keeping the record and they're spending the intense time of making sure the blood pressure is controlled. –D1, Female, 51

Other research has pointed to the value of thorough recordkeeping over time (Carter *et al.*, 2018). For example, systems could potentially make up for discontinuities across doctors by providing thorough records of past appointments. With respect to video appointments, this could possibly include recordings of the video call itself; I return to this topic in subsequent sections on privacy and video calls.

In addition, doctor participants wanted to ensure that video-based appointments were booked ahead of time and not something where a patient could call them at any moment. Doctor participants did not want their personal life to be disturbed by getting random teleconference requests. While this is a feature of current telehealth applications, several of our doctor participants were using Skype to see their patients, which meant these doctors could be contacted by patients anytime if they wanted. Hence, they were worried that video conferencing could be easily abused by patients who were unaware of interpersonal boundaries, if patients were able to get in touch with their doctor at off-work times. This suggests video appointment systems need to be designed with particular types of call settings in place, e.g., one-way calling.

3.4.2. Camera Work and Examination

In this section, I explore the camera work that is needed for video-based appointments and examination techniques like palpation. Participants also talked about how various types of appointments would or would not be suitable for video conferencing given the types of camera work that would be required.

Visual Inspections via the Camera

Both doctor and patient participants recognized the importance of seeing a patient's whole body. Doctor participants who already did video-based appointments said they most often did psychiatric consultations over video as they did not usually require physical exams via palpation or a large amount of camera work to see the participants. Most often it was good enough to just see the patient's face, which was generally easy to do over video; for example, a phone could simply be set down on a table and leaned up against an object to show the patient's face. If using a laptop, it was generally easy for patients and doctors to show their faces during conversation since the camera was in a fixed location. For these reasons, most of our doctor participants thought that psychiatry was the most appropriate type of appointment to be conducted over video; prior research has found similar results (Shore, 2013). Beyond these findings, I found that seeing a patient's entire body during a video appointment was seen as being valuable, even if for psychiatry-focused appointments or consultations mostly focused on verbal exchanges. Participants said that they would like to see patients' body conduct, such as fidgeting with one's hands or feet. However, the challenge is that such information could be lost as patients generally held their phones close to them so that the entire body was not shown. Patient participants also thought that showing their whole body could help the doctor to discover subtle symptoms which patients could consider irrelevant. They said that such an aspect normally would not be practical because patients would likely hold the phone in front and solely show their face.

> For this one (sleeplessness), you just need to see their face. But a lot of times you can see that they're anxious, they're fidgeting with their

hands. And if they're holding their phone you can't really see this. –D2, Male, 31

Providing doctors with a larger field of view during video-based appointments could help with this concern, yet it was seen to be difficult to achieve in practice as it could require a patient to place the camera far away from them in order to capture their entire body. At such a distance though, seeing what was in a frame on the camera would be challenging given the small size of phone screens and the patient's distance from the camera. Additionally, developing a set of etiquette guidelines for use during telehealth appointments might also be beneficial, such as holding the phone at a certain distance or angle, or placing the phone on a surface to make more of the patient visible.

Like prior research (Landow *et al.*, 2014), I were told by doctor participants that dermatology was another specialty that could possibly be suitable for video-based appointments; our work extends this with knowledge related to camera work. Here both doctor and patient participants felt that seeing the skin clearly over video could be quite challenging because doctors need to see the nuances of the skin area, including, for example, the texture, and how the skin may be raised.

> If you see someone, you can feel the texture. But you need to sort of move it around, how far raised it is, if it's rough, or smooth. I don't think you need to necessarily touch it, but the resolution needs to be well enough that you can see a good picture…You need to like move it around to see how light goes off of it. –D2, Male, 31

Poor resolution or lagging video was seen to make a diagnosis of skin conditions difficult and unreliable. Moreover, a patient's inability to hold the camera steady and at the correct distance from the skin to allow the camera to properly focus could be an issue. Issues around a lack of focus could be difficult to detect, especially if showing close-up views of a person's body where the entire image is of a similar colour and shade. Alternatively, it might be possible to envision the incorporation of augmented reality into telemedicine applications, which is able to demonstrate nuances that cannot be captured by the naked eye through video. Some participants also suggested that taking a clear picture would be better than using video for such instances. For example, some common video calling systems (e.g., FaceTime) now allow still photos to be captured and shared in the middle of a video call. Yet, one doctor participant added that three-dimensional information would not be known from a still image.

Our video scenarios depicted actors capturing various parts of their body with mobile phone cameras, e.g., leg, throat and arm. Both our doctor and patient participants felt that some areas would be difficult to capture even though the phone is highly mobile compared to a stationary camera on a laptop. It could be hard to see what the camera was capturing due to its orientation. For example, when holding the camera in front of one's mouth for the *Cold* scenario, the patient cannot really see what is being captured by the camera since the phone has to be held so close to the patient's face. Similarly, when holding the camera to capture the back of one's leg, it was very difficult to see what was on the screen and whether the correct part of one's leg was being captured by the camera since the phone display was at an awkward angle.

> Well, [phones] might not be the best devices and they might not be able to [show the area], for example, a person coming in on a rash on the back thigh. –D6, Male, 32

This suggests alternative solutions that utilize different types of cameras. For example, systems could be adapted to share video data from other additional camera sources (e.g., an external USB or Bluetooth webcam) that allow a person to capture camera footage while seeing what is being captured on a separate display. Other solutions might allow patients to place their phones on a desk or table and "scan" their bodies by taking video that is transmitted to the doctor.

Doctor participants also hoped that examining patients' body parts via the phone camera would not occupy extra time. They explained that they may need to guide patients to shift their phones to get the best view if the body parts were difficult to capture. Yet this was seen to possibly require a lot of dialogue back and forth between the doctor and patient, e.g., Doctor: "Move the camera to the left." Patient: "Which way is left?" D: "Ok, now move it closer…. Oh, too close, now further." While systems could be augmented to guide patient users to capture good video through techniques such as overlays on the screen (e.g., showing arrows that direct the patient which way to move the camera), the screen may not always be seen by the patient when moving the camera around. Given such complexities, doctors thought it could save time if patients took images ahead of the consultation. That way, they could capture one or more images, inspect them for quality, and re-take them if needed. Even still, doctors raised concerns about quality because they thought that patients may not recognize how 'good' an image had to be in order to be useful or what should be included within it. They also thought that a patient may accidentally capture the wrong thing, and they may have to redo images during the appointment. This would take up valuable time.

> If they did it in advance and it wasn't good enough, there'd have to be a way for them to retake the picture and upload it quickly. So you're not just waiting a long time until they get a proper picture uploaded and sent to you. –D4, Male, 45

When it came to showing specific body parts, patient participants thought it would be difficult to conduct actions with both hands occupied, e.g., lifting a pant leg and showing the injured area. They could set down the phone, but it could be challenging to find an object to easily lean it against in order to still capture the right view for the doctor. Patients also felt that it could be hard to hold a phone for a prolonged period of time during an appointment, especially if the phone had to be held at awkward angles, e.g., trying to show one's back.

> I can see that given a long consultation, the patient probably gets tired that she has to hold the phone and it's not comfortable anyway…The patient only has two hands to set and hit the body. With the mobile phone, she really needs one hand. – P17, Female, 42

Palpation

Palpation is a process where doctors physically check a patients' body using their hands. For example, when in person for an appointment like our *Fell while Jogging* scenario, the doctor would inspect the patient's abdomen by pushing on it. Some patient participants thought that they could be coached by a doctor in the remote location to perform palpation on themselves. Others felt that it would be difficult to follow the doctor's instructions via video. This was especially the case because not only would they have to perform the palpation themselves, but they would have to do so while also simultaneously holding their phone and directing its camera at the right location. Both tasks were seen to be quite complex on their own and the combination of doing them together was even more problematic.

> The patient could probably apply less pressure than needed to feel versus a doctor. A doctor can physically tell if it's serious or not instead of having patients to let him know. Because this is not a common cold or a sickness. –P6, Male, 24"

Unsurprisingly, most doctor participants believed that palpation was the most challenging exam to perform over a video call because doctors were trained for years in how to properly perform palpation. They thought it would be extremely difficult for patients or their family to perform such actions themselves as part of a video appointment. For these reasons, they felt that appointments that might involve palpation would not be suitable for a video visit. This validated a previous study that showed doctors were reluctant to use video consultations because of one's inability to perform physical examinations (Kvedar, Coye and Everett, 2014).

> You might have pain, or you might feel the edge of the organ come down like the liver, spleen…if you're pressing lightly, even if they take a deep breath, you may miss the spleen or gallbladder cause you're too superficial. –D4, Male, 45

Several doctors thought that basic palpation could be done by patients themselves if the doctor knew the patients' history well and could reasonably predict the problem based on the currently described symptoms and past issues. One participant thought that palpation could possibly be replaced in the future with new techniques that might better map to the affordances and capabilities found in video appointments.

These results suggest that, if designs do attempt to support some form of patient palpation in the future, much guidance is needed. For example, systems would need to support patient users by providing visual and audio guidance on how to conduct such techniques, potentially before the appointment to save time. Systems could also be designed to better support camera work with respect to the aforementioned challenges around holding or placing a phone in a specific location so as to both touch one's body and capture the appropriate video on camera.

3.4.3. Relationship-Building over Video

Both our patient and doctor participants recognized the importance of combining verbal and non-verbal communication behaviors to show care during appointments. Doctor participants said that proper verbal and body language could convey empathy and help establish rapport. Verbal language involved active listening or changing the tone of one's voice. Body language involved gaze contact, nodding or adjusting physical distance when listening or explaining things to patients. This was consistent with Heath's work in the 1980s (Heath and Nicholls, 1986). The doctor's body posture and gaze can be easily perceived by the patient during face-to-face interactions. Yet, as suggested by previous research (Gordon *et al.*, 2020) and our doctor participants, such behaviors could be affected in a video-based appointment. Non-verbal behaviours could be difficult to convey and, in turn, understand.

> Often, I'll be sitting here (in front of the table) typing … If they get to a certain point, I'll stop typing, put down my pen, I presume like a distance of about three feet, to show to them, not that I wasn't listening before, but to emphasize that I am really listening to what they're saying. – D8, Male, 36

As was described by D8, doctors would not be able to perform certain actions over video in a natural way such as turning their body toward the patient or shifting their gaze to the patient. This could be because the interactions are seen through a computer display and there is no need to turn one's body. Physical distance can also be challenging to determine. While it is possible to be a certain distance from a patient in person in order to be considered socially acceptable, such physical distances are very difficult to judge in a video call. As a result, a doctor might be considered too far or too close to the camera, making it seem as though they are disinterested or socially awkward.

Patient participants described similar concerns about eye contact and the attention of the doctor. They said they might not be able to tell if the doctor was looking at them. This could be caused by the disparity between the camera and one's gaze orientation to the display (Grayson and Monk, 2003).

> I think over video call it's hard to know if the person's attention is only on you because they might have other tabs open and stuff…Whereas if you're in person, you know through their body language and through their eye contact that they're actually focusing on you. – P1, Female, 19

Research has tried to remedy this issue, by correcting eye gaze during video calls to create eye contact (Hsu *et al.*, 2019). This feature could be incorporated into telehealth applications to aid rapport-building. However, the problem of eye contact is not only present in virtual visits, but patients also feel disengaged during in-person visits when doctors look at medical records (Roter *et al.*, 2006; Chen *et al.*, 2011). Given that during video-based appointments doctors are already looking at their computer screen (to interact with the patient), doctors might be able to look through a patient's medical records while still looking in the direction of the patient, potentially removing this issue.

With the aforementioned challenges in mind, participants felt that video-based appointments could be more appropriate for those who have pre-established relationships, or who are used to using video conferencing. Our doctor participants felt that an initial visit with a patient should be in-person and not over video. This was also found in a previous study in 2019 (Chudner *et al.*, 2019). Often initial visits with patients involve full examinations which doctor participants said could not always be done over video. They also believed that a sense of rapport and emotional connection could be built better in a face-to-face setting, where it was very easy to see one's body language and facial expressions. This was valued by doctor participants, especially for sensitive situations like the *Domestic Abuse* or *Drugs* scenarios.

> I think establishing that trust and rapport with somebody, maybe with the first time that they've had a bout of depression, then they come in. Giving you advice over the phone, maybe it's not received very well the very first time. –D8, Male, 36

I was told by both patient and doctor participants that patients with mental health concerns would need a stronger emotional connection with their doctor. Previous research has attempted to do this by providing real-time feedback to doctors and patients about their rapport-building behaviors (Faucett, Lee and Carter, 2017). Our doctor participants also added that such a connection could still be conveyed over video, but only if they had already built a relationship and patients had developed the perception that their doctor was empathetic to their situation. The familiarity of the doctor's voice and workflow could also create a sense of connection.

> They know how you manage, they know the way you talk, they know your tone of voice, and when you talk quiet, you talk loud, how your voice changes... So when you actually talk to them on video conference, even if they don't have you there, they can hear those and they know that's what he does with his voice when he cares. –D6, Male, 32

Doctor participants were also worried that patients might be less engaged during video-based appointments due to distractions around them. Some had experienced this in their past video appointments, e.g., children coming into the room and distracting the patient. Another participant recalled a situation where a patient answered the video call for an appointment while driving, which was clearly unsafe. Such challenges could make it hard for doctors to build relationships with their patients since good relationship-building relies on attentive communication.

> There's a mutual shared environment [in face-to-face appointments]… There is an undeniable difference in your communication and connection with another person when it's via video conferencing… I have kids in the back background, so that, that element of, yeah, you just can't totally know what the environment is like. –D7, Female, 44

> Many of these people might be parents, many of these people might be calling from somewhere where they might be distracted. So I think the engagement level could be slightly diminished. So many distractions can be present, whereas when you're in a doctor's office, it's quiet. There's nowhere else to look. There's nothing else to see. –D8, Male, 36

Video appointment systems might therefore include reminders or cues to ensure that the patients are treating the visit similarly to how they would an in-person appointment, and to discourage multitasking or unsafe behaviors.

3.4.4. Privacy and Control During Video Appointments

Doctor participants talked about being able to control the space and context of a face-to-face appointment. They were able to manage, for instance, who would have access to their conversation, how to control the workflow to protect patients' physical privacy, and how the consultation in the office setting could protect patients from being harmed. Yet, video appointments could undermine their control abilities. For these reasons, I explored ideas around anonymity and video recording with participants to see how they would react to them and whether these design ideas would help to mitigate their concerns. I describe these ideas in detail in this section.

Control of Access to Conversations and Misinformation

First, I was told by doctor participants who had used video-based appointments that their patients called them from a variety of locations such as their bedroom, office, or, even in their car, which were far more diverse than what was shown in our video scenarios as a private space in a home setting. They said that patients appeared to show little concern for their privacy when selecting a location. Thus, doctor participants felt that they would not be able to control the appointment in the same way that they might be able to in the office in terms of who else would have access to their conversations with patients. Sometimes video calls were done with other people around, which the doctors were not always aware of. Such varied locations for video appointments were seen as being problematic because it took control away from the doctors. This meant they may not know who could see or hear the call, which might introduce additional liability concerns.

> The man is driving, and the wife is doing telemedicine with me. Obviously, the privacy is gone at that point because whatever you say that man's going to hear, the kids are going to hear, but that's what they chose. –D6, Male, 32

> I'd ideally always be in a secure environment where I'm not worried about my end of the conversation, but from their perspective where are they? Who's sitting there? Who's observing? How do I know? So they'd have to feel comfortable with that. –D8, Male, 36

Doctor participants also talked about the varied locations in which they were able to conduct a video call. This might be in their clinic office; however, given the flexibility of video calls, it could also be in their home. They believed that it was important to notify their patients of the risks of possibly being exposed to their surrounding environment as well as risks of cyber security. For example, one participant listed these risks on her appointment web page; such a warning could be added to telehealth applications as well. She held video-based appointments from her home office in the late evening and this posed a possible risk for patients since others occupied her home too. She said that she made patients aware of the situation and they could accept the risk.

> My daughter wakes up in the middle of the night and comes hopping on by, they see in the video camera there's this little kid. But the thing is they know me, they know I'm doing it my home. They know that she is going to sleep in the next room. They accept that risk. –D1, Female, 51

Patient participants brought up concerns with the *Domestic Abuse* scenario. Several patient participants believed that privacy and control issues could occur if the patient met other people on the way to the clinic or in the waiting room. In comparison, attending a video appointment from home would be a wise choice such that bruises could only be seen by the doctor over video. Yet, some other patient participants said that staying at home could bring the victim additional risk of being discovered by the perpetrator during the consultation. That said, participants were speculating and had not been in such situations before to fully understand the risk posed.

> Because you don't want neighbours to see anything or a random stranger to think, 'Oh my god, she got beat up. She's in a bad situation.' – P21, Female, 68

> Consulting with a doctor at home will increase the risk of abuse again.
> – P3, Female, 21

To help alleviate such concerns, telemedicine systems could incorporate non-verbal information channels, such as ‘reactions’ to let the doctor know that the patient is in danger, not alone, or are concerned about privacy. This could enable patients to provide non-verbal feedback to the doctor when their surroundings may not allow for them to do so verbally.

Doctor participants mentioned that it would be easier to discover physical abuse during in-person appointments as doctors are able to observe patients’ whole body rather than only their face. The camera view during a video appointment could easily limit this ability. Further, doctor participants said that if patients did a physical exam in the office where their clothes needed to be removed, there would be an opportunity to notice bruises, which could be a sign of abuse. In contrast, if the appointment was conducted over video, such areas may not be shown on camera or might be concealed.

> Cause the abusers of kids, they will abuse them in places where the clothes are covered… So when you're doing an exam where you lift up their shirt to listen to their lungs…wait, a big hand mark here on the back… But obviously if the person on the video is the abuser, they're not going to show them. –D2, Male, 31

Doctor participants also talked about not being able to easily see other people such as parents during a video appointment. Parents could, for example, easily be off-camera and directing children in particular ways during a video appointment. This could be helped by having multiple camera views, or a wider image altogether. Nonetheless, doctors felt like they could lose control over how they were able to conduct the appointment.

> When I ask a question, is child always looking at mom, or is mom changing the answer or the story or shaking her head and these kinds of things…I don't think teleconferencing would be something appropriate for that. –D8, Male, 36

Another doctor participant explained that people with varying cultures had different perceptions around what was considered appropriate regarding privacy. When in person for an appointment, he could ask family members to leave the examination room, yet during a video call this was seen as being more difficult.

> On a telemedicine, that becomes very difficult because I have to manoeuvre in the office. I end up manoeuvring around to find a way to ask the question…I've done is that … "I really can't hear you because your kids are on, can you just take the phone and go into…a different room so I can hear?" But that is not always possible cause sometimes there's no kids. –D6, Male, 32

Once again, systems could implement a method of sharing this information with doctors through non-verbal channels, to protect the patient's privacy and discretion.

Similarly, patient participants shared concerns about not knowing the environment on the doctor's side. They did not know if there was someone else watching outside of the camera's view, although they were aware that doctors should obey confidentiality. A similar finding was found in prior work, though in that case, it related to work colleagues possibly overhearing a patient's video call (Powell *et al.*, 2017), which presents a different context than my finding.

Protecting Physical Privacy

Control was seen as being especially problematic by doctor participants for situations like the *Private Parts* scenario that they watched in the video scenarios where the patient was asked to show their genital area to the doctor via the phone's camera. When appointments were in-person, there was a standard protocol to protect patients' physical privacy as was told by doctor participants. First, the patient would have a private space to change their clothes. Then, the doctor would let the patient cover their body with a sheet. In this way, the doctor would only see what was necessary to expose to them. The doctor would inform the patient of what they needed to examine in advance. Sometimes, there was also a chaperone that accompanied the patient, requested either by the doctor or the patient, if they believed it was necessary. The procedure ensured that the physical privacy of the patient could be well protected during in-person consultations.

> You do a lot of things like covering them up with a sheet, even though the patient goes, well, this is stupid. … And you're just going to remove the sheet and have a look at it. But it's the kind of thing where you know, you leave the room for them to get changed and they'd put on the gown and then you remove the gown just to the piece that is going to be exposed and … you always give that privacy aspect. –D1, Female, 51

In comparison, such protection could be challenging if the doctor wanted to examine the patient over video. Doctor participants were concerned about how such an examination could be done over video. They generally felt it was not appropriate to have a patient expose their private parts without a similar procedure as in an in-person visit. Such procedures had not been established in their practices though.

Some doctor participants suggested solutions that could help mitigate the aforementioned concerns. Here they felt that patients could easily control the visual inspection by simply turning off the camera, redirecting it, or even terminating the consultation if they felt uncomfortable with their doctor's instructions. This might even give patients more control over such sensitive exams when compared to the same types when in-person.

> I think there'd be a limit to the harm that could be inflicted. Cause if a patient felt uncomfortable, they could just terminate the visit … no one would ever of course be touched inappropriately. If they could control what was viewed by the person on the other end before it went live and if it was destroyed... –D4, Male, 45

When reacting to the *Private Parts* scenario, doctor participants talked about the possibility of encountering malicious patients who may exploit an appointment for sexual gratification and thereby infringe on the doctor's privacy and control over what they were seeing. Some had felt suspect of certain situations in their past appointment history. They said usually there would be a chaperone when doing sensitive exams in the office. On one hand, this ensured patients received an appropriate exam, and on the other hand, it was to protect doctors from being harassed. Doctor participants felt that in a video appointment they could become vulnerable in instances involving examining sensitive or private areas of a patient's body.

> There are also some patients who are, who want to show you their stuff…Creepy, right? And it just feels like this could go wrong. – D1, Female, 51

On the other hand, the patient participants in the study were uncomfortable to show their private parts to the doctor over video. Most patient participants raised issues such as cyber security or the unknown environment on the doctor's side and not knowing if someone was standing outside the doctor's camera view but still able to see the screen.

> If I'm a patient, I'm thinking what the doctor's thinking now after seeing my area. She must be thinking about your parts… I couldn't trust this person and what she might be thinking. So that's running in my head… –P13, Female, 34

Moreover, there was a gender difference in relation to topics such as one's private parts. All of the male patient participants felt comfortable talking about sexual issues with their doctor regardless of the doctor's gender. Yet, most female patient participants felt differently when encountering sensitive topics. Some female participants preferred to talk with a female doctor.

> Especially if it's not my regular family doctor, I would not want a male there. Actually, even if it was my family doctor, I usually try to find the public nurses, like female. – P9, Female, 32

Thus, the results show that using video-based appointments for situations like the *Private Parts* scenario would not be appropriate for everyone. Those patients who are comfortable with it would need to rely on app-based controls to easily turn on/off the camera at varying points when revealing one's body, akin to how doctors leave the room when a patient is undressing. To help protect doctors from visual harassment by patients, they too could have controls to easily turn on/off or mask the camera view.

Control of Patients' Safety and Privacy Related to Sensitive Topics

Control in relation to providing support was also limited for situations like the *Sleeplessness* scenario. Doctor participants said they were able to protect patients from being harmed or suicidal when in the office by calling their office staff for direct intervention. In contrast, it would be difficult to give instant assistance during video-based appointments as doctors did not even know the patient's specific location.

> If there's any concern about the patient being psychotic, aggressive or suicidal, where you can't act right now to provide them with support. – D9, Female, 58

To help alleviate such concerns, video appointment systems could incorporate some sort of panic button, to be used by doctors when they believe a patient is in danger, and which could trigger specialized personnel to go to their location. This would be similar to several safety applications that exist, which track GPS coordinates and alert designated individuals or local authorities when the device is activated (Islam *et al.*, 2018).

Video consultation could also benefit patients in certain situations. For example, doctor and patient participants felt that patients with psychiatric issues or those who might be hesitant to go to the clinic, such as teenagers or victims in the *Domestic Abuse* scenario might be more apt to have an appointment via video. Both doctor and patient participants felt that video conferencing would provide an alternative choice to receive healthcare and maintain a connection. However, doctor participants were concerned that they may lose track of such patients if they did not come in person, and this challenge would need to be rectified.

> I have one patient with a very severe agoraphobia, so she is having significant difficulties getting out of her house. … all her follow-up has been through telehealth, that's been invaluable. –D7, Female, 44

> The last thing the teenager wants to do is to be dragged into the office once a week or every two weeks just to tell you what's happening… They have no problem going on the Skype and touching base because it hasn't interfered in their life. –D1, Female, 51

Sometimes the video visit was believed to be a good way to protect patients' privacy related to disclosing sensitive information. One doctor participant said that it was common to see walk-in patients in-person with sexual health issues similar to the *Showing Private Parts* scenario. The participant speculated that it could be because patients were sometimes embarrassed to talk about such issues with their 'regular' general practitioner. This was also confirmed by ten of the patient participants. They felt that presenting such issues over video to one's doctor would be less embarrassing than doing so in person. It could be explained that the use of video communication increased their social distance, which might make it easier for patients to disclose their situations.

Patient Anonymity

I asked patient and doctor participants about how they would feel if the patient could have a choice to blur their face to hide their identity in situations like the *Domestic Abuse* or *Private Parts* scenarios, in which patients might feel embarrassed or uncomfortable. This could be a way to make patients feel more comfortable but might involve giving up some level of control. Such video obfuscation techniques came up in other studies on video conferencing and media spaces (Boyle and Greenberg, 2005); thus, I asked questions in relation to it. Anonymity through blurring was valued by some of the patient participants, while several patient participants worried that blurring faces would make it difficult for doctors to understand patients' facial expressions and assess their psychological status.

> I think [blurring faces] is very good. For example, when you want to go there and talk about drinking or marijuana or private parts, these kinds of things. I know people that don't go to doctor at all just because they don't want to talk about it with another person. – P12, Female, 33

> You can read the expressions of the people's face, eyes. 'Okay, this lady is really scared ... or she knows it's a minor thing, so she's not really worried about it'. – P21, Female, 68

In comparison, many doctor participants did not fully comprehend patient participants' concerns and felt this would be strange and undesirable. First, they said that doctors would maintain the confidentiality of patients' medical records, so anonymity was likely not necessary. They also felt it was their duty to not be judgmental about patients' situations and patients only needed to disclose what was necessary for diagnosis. Furthermore, they believed that observing patients' facial expressions was essential to avoiding misinformation and misdiagnosis.

> Often someone comes in, "oh I think I have a UTI," but really then you dig more and more and I can tell them in their face, maybe there's something more going on, but that's because I can tell their reaction to some of the questions I ask. –D8, Male, 36

Thus, it appears that providing masking options may not be necessary or helpful for medical purposes.

Video Recording

Doctor participants and patient participants raised serious concerns about malicious video recording during video consultations. They felt that video recording could be done surreptitiously without the other party knowing. This would create privacy and control issues. Patient participants were worried that doctors could have access to video from previous appointments without their knowledge or permission. In contrast, doctor participants generally felt that it was acceptable for patients to record video appointments with the doctor's permission such that they could playback the doctor's instructions or diagnosis as needed. Yet, they also had concerns about being exposed to lawsuits if there were malicious patients who recorded the video without asking for permission. One doctor participant said that doctors might also face the risk of being accused of illegitimate video recording of the patient.

> Could anything ever come back to me in the future that you know? 'Well, I think the doctor recorded my private exam.' How do I prove that I didn't? Right? If they were in my exam room, like Duh, I didn't record it cause there's no equipment. –D1, Female, 51

Telehealth systems might therefore be equipped with sensors to monitor the recording of appointments, and alert the other party when activated.

3.5. Discussion

I now discuss the findings and design implications for video-mediated doctor consultations in the home setting. In order to better understand how the study results are applicable to present day and future technology designs for video-based appointments, I comment on an analysis of four representative commercial video consultation applications throughout the Discussion section. The systems are listed in Table 3.2 and include TELUS Babylon, VSee, Medeo, and Doctor on Demand.

Table 3.2 Features of Commercial Video Consultation Applicaations

	Design Features	Telus Babylon	VSee	Medeo	Doctor on Demand
1	Type of devices supported	Smartphone	Smartphone or computer	Smartphone or computer	smartphone
2	Number of cameras	One	One or two with a peripheral device	One	One
3	Same doctor each time	Generally no	Yes	No	No
4	Video recording	Audio only	No	No	No
5	Support peripheral devices	Medical alert pendant for older adults	Stethoscope, otoscope, ultrasound, ECG, etc.	No	No

For example, with TELUS Babylon, patients can select a time slot at the appropriate time, like how they make appointments in person. A doctor will initiate a video call with the patient on their smartphone (Table 3.2, Row 1). If patients want to see the same doctor, they have to call a 'TELUS assistant' to check when the doctor would be available (Row 3). Only one phone camera can be used at a time, though users can toggle between front and rear-facing cameras on their smartphone (Row 2).

Appointments are audio recorded for records and the safety of the patient. Patients can request audio recordings by contacting customer service (Row 4). The app supports a few additional peripheral devices (Row 5). Users can enter their symptoms when booking an appointment, but the system does not appear to screen appointment types on its own (Row 6). Babylon is marketed for appointments about infectious, psychiatric, digestive, dermatologic, and traumatic situations as well as for providing medical advice in relation to sexual health, lifestyles, or medications. As seen in Table 3.2, multiple similar services exist and have comparable device and camera features, possibly leading to interaction design challenges and opportunities for research. Other applications typically have either the same or subset of the features found within these applications. Of course, there are many other applications that have been created for video-based doctor appointments. The set I have chosen to present and explore is similar in design to many others. Overall, I found that the four systems I analyzed do not include many of the design features that the results point to as being important; I elaborate on these points throughout the Discussion section.

3.5.1. Virtual Clinic and Appropriate Utilization

First, the study results illustrate that there is strong value in considering video calling software for doctor appointments as a mechanism to help create a better balance between a patient's and doctor’s time and availability. In-person appointments are typically arranged to benefit the doctor’s time and schedule, where patients must often wait on doctors. In fact, the patient participants’ main perceived benefit of video-based appointments was saving travel and wait time. They also recognized the benefit of utilizing idle time for other activities as opposed to solely waiting in a clinic. When shifting to video appointments, it is critical then to **consider what design features can be created to support better use of time for patients.** For example, designs could inform patients about their likely appointment start time (even if scheduled for a specific time) and how much of an approximate wait they have. This might be similar to phone calling systems that provide callers with ‘wait time’ information, e.g., messages such as “An operator will be with you in approximately 15 minutes.” This idea could be extended to video appointment systems to provide more detailed awareness information such as how many patients are ahead of them and the expected wait times for each appointment, thus providing similar information to in-person appointment waiting while also extending it in useful ways. Patients could then engage in other activities at their home while they wait for their appointment to begin. Some commercial video consultation applications, such as VSee (Table 3.2, Column 3), support a 'virtual waiting room' in which doctors or coordinators are able to see the list of patients who are in a queue. However, such features are not available on the patients' side. More broadly, I do not see such features in other video appointment applications nor in the related literature. Overall then, the applications I analyzed in Table 3.2 do not consider this design recommendation deeply, if at all.

The study results also point to the strong value that doctors can gain from seeing patients waiting, interacting, or walking between locations in a clinic. Video appointment systems take away this opportunity since they focus on just streaming the appointment itself. For this reason, there is an important opportunity for designers to **consider how to capture and share types of supplementary information about patients before an appointment begins**. For example, one possibility might involve applications that are designed to walk patients through scripted video capture such that particular types of video footage can be recorded prior to an appointment, e.g., on-screen instructions might say, "Position your camera approximately 10 feet from you. Now capture a video of yourself walking across the room." This type of feature is akin to watching a patient walking through a medical clinic and was not in the applications I analyzed. Here it would be important to illustrate the rationale for this type of footage to patients, so it is understood as valuable. Computer vision algorithms could also be incorporated into systems to track whether the necessary patient movements were performed correctly and done within the camera's frame in order to better support the necessary camera work. In turn, it would also be important to not overburden doctors with video footage that they have to view prior to an appointment; this suggests carefully curated video clips, which could possibly be done algorithmically or through user interfaces designed to help patients cut and trim video clips prior to being shared. Data from other sources, such as health apps that track walking, might be useful for providing more holistic information to doctors. Across all of these solutions, designers would need to consider the users and their abilities. When analyzing the systems in Table 3.2, I found that none of them include these types of design features.

3.5.2. Camera Work in Video Appointments

The study results show that it is critical to think of video calls for doctor appointments as being much different from a typical video call that one might have using systems like Skype or FaceTime. Video calls for work or home life most often focus on seeing faces and conversing (Judge and Neustaedter, 2010). On the other hand, video calls for doctor appointments include conversations, but, often more importantly, showing various parts of one's body to a doctor, which is not always easy with a mobile phone. For these reasons, I feel **it is critical to think about *both* software and hardware when designing video calling systems for doctor appointments**. When looking at the commercial systems I analyzed from Table 3.2, I see a focus nearly exclusively on software, e.g., an app running on a standard mobile phone with an embedded camera. Hardware is typically only considered in the form of peripheral devices that can connect with a mobile phone, such as a smartwatch that provides health data via a step count.

First, designers must **consider the type of camera being used and what it is able to capture.** Both doctors and patients recognized the importance of seeing patients' whole bodies, similar to how doctors see them in the office. It is essential for doctors to obtain patients' general status by observing their facial expressions and body language. The issue has also been mentioned in (Aggarwal *et al.*, 2016) where doctors desire high-quality video cameras so that they can notice nuances in patients and their behaviours. This means that mobile phones alone on the patient's side may not be ideal for video-based appointments because the front camera of most smartphones at the present time is not able to capture video of a person's entire upper body while being close enough to the user so that they can see the doctor on the phone's display. These findings suggest that cameras need to have large fields of view, or it should be possible to place them at a distance away from the patient to capture a broader area on camera. Of the applications listed in Table 3.2, only VSee supports an external camera, which would allow the application to meet this design suggestion if an external camera had a wide field of view.

Second, and related to the previous point, it is critical that designers **consider decoupling the camera from the video call display (the mobile phone's display).** If a camera is placed far away in order to capture a patient's entire body, they may easily not be able to see the display to see the doctor or what is being captured by their camera, which would impede camera work. Doctors also sometimes need to see particular body parts that might be difficult for patients to capture with a mobile phone camera alone. For example, a patient may need to capture an image of their back and not be sure that it is in view on their phone because the display is behind them and out of sight when holding the phone behind their back. A possible design solution could involve a stand-alone camera that can be separated from the display so that the patient can capture the video footage while looking at a display to see what the camera is pointed at. In this case, it could be useful for a camera to be able to be easily held or adhered to a surface, e.g., a wall or a desk, to facilitate image capture. This also illustrates the importance of hardware that can allow a camera or mobile phone to be easily set down in a given location where it does not fall over. Another idea could involve using a smartwatch to display what the phone's camera sees when holding the camera behind one's back. Of the applications listed in Table 3.2, again, only VSee supports an external camera, which would help support this design suggestion, if the user interface made it easy to manage the external camera and decouple the camera from the display. While the results showed that palpation by patients themselves may not be possible at the present time, if palpation is possible in the future, it will need to involve hands-free capture of a patient so that they can use their hands or peripheral devices to press their own body. In this way, special-purpose mobile phone stands would help patients set down their phone and direct its camera at their body while they perform their own palpation.

These camera work challenges all suggest design opportunities for apps and devices that allow doctors to observe patients in different ways. Hands-free video conferencing systems such as Facebook Portal or similar systems designed in previous studies of family communication that are similar to portable picture frames (Judge *et al.*, 2011), as well as telepresence robots (Neustaedter *et al.*, 2018; Yang and Neustaedter, 2018), could be candidates for video-based appointments. Such systems are generally equipped with large camera view angles and mobility such that patients can be in a private space in their home without having to hold a phone or tablet all the time. Yet many people may not have specific devices such as a Facebook Portal or more expensive telepresence robots. This suggests that, instead, camera work might best be supported by smaller stand-alone cameras (e.g., akin to a GoPro camera) that could be placed in certain locations and paired to a mobile phone. Such cameras are popular for capturing first-person views of sports activities, e.g., skateboarding, skiing. The appointment apps that I analyzed (Table 3.2) only contained the most basic of camera features, focusing on the use of a single camera, and did not have features found in these other types of devices.

The idea of multiple cameras for video conferencing is not new in non-health situations and could be highly valuable for doctor appointments given the study results. Previous studies use multiple cameras to present multiple views of the same context (MacCormick, 2013; Unver *et al.*, 2018), which have shown to be able to better support shared views and experiences during video conferencing in non-health situations. Yet, the camera work for doctor appointments would be different in that it will often require intensive and effective collaboration between the doctor and patient to position and orient the camera in different ways. For example, doctors usually need to explicitly ask patients to show body parts or perform certain actions over video. Doctors prefer not to spend valuable appointment time on such 'setup' coordination. Thus, designers should **consider opportunities for systems to be able to help patients configure their camera and video conferencing setup in advance or mechanisms to support the pre-recording of things that doctors are likely to need to see**. For example, systems could be designed with on-screen feedback that helps patients align themselves in the camera view. Or, systems could ask patients questions about their symptoms, and have them record certain video clips before the appointment that are likely to be needed by the doctor. Of course, this may not always get the correct footage, but it could help reduce time in some cases.

3.5.3. Relationships, Control, and Privacy

Relationship building and rapport can be important for many doctor-patient relationships. Both doctors and patients believed it would be difficult to build rapport when meeting for the first time over video without a pre-established relationship. Challenges exist in terms of seeing body language on a small display, maintaining eye contact, and seeing gestures, all of which are common issues with video calls in general when using a smartphone. While eye contact is notoriously hard to 'get right' in a video system, there are likely more straightforward opportunities to address what one can see of a doctor or patient's body in a video call. As such, designers should **consider**

opportunities to enhance the physical embodiment of both patients and doctors. This could involve coupling larger displays with mobile phones so that the remote person can be shown on the large display at life-size or near life-size. For example, a mobile phone could be connected wirelessly to a television within the home to show a doctor's video on a larger scale so that it is easier to see body language and gestures. Similarly, applications could support the use of different types of devices on the doctor's side, such as laptops or computers, if they do not already. While I do not know what the experience is like for doctors with the applications I analyzed from Table 3.2, I do know that none of the applications focused on making it easy to couple the app with a large display for viewing aside from using a mobile phone's built-in features, which may be difficult for many people to understand. Prior research for video communications, in general, has explored projecting people in real size (Pejsa *et al.*, 2016) as a form of telepresence, or capturing people's 3D models (Orts-Escolano *et al.*, 2016) and presenting them virtually in the same virtual space. Such approaches of remote presence may make the interactions more natural but are quite forward-thinking and not presently accessible for video calls with doctors in home environments.

Most of the patient participants and many doctor participants were hesitant about privacy-intrusive scenarios, such as exposing one's private body parts over video. Nevertheless, some doctor participants were open to such exams if patients behaved appropriately. Yet, the challenge was that patients were unlikely to drape themselves properly and, thereby, exposing parts of their bodies that are otherwise draped during in-person appointments. This may create issues around risking patients' dignity. As such, designers should **consider features that allow patients to selectively expose portions of their body over a video call.** Here, lessons could be applied from in-person visits where patients are generally left alone to get changed before an exam and are given a cover sheet to guarantee that only a specific body part is seen by the doctor when examining the patient. For example, applications could allow patients to pause the video stream on their side while still allowing them to see what is being captured by the camera. They could orient the camera and perform the necessary camera work to get the right area of their body in view. They could also use a form of 'virtual drape' to cover up the rest of their body digitally. Here the patient could assign an area on their body to be shown, and an algorithm could recognize the area and ensure that the patient's body outside of it would be hidden from the doctor regardless of how patients hold the camera or move their body relative to the camera. In this way, only the uncovered area of their body would be transmitted once they turn the video stream on again. None of the applications I analyzed in Table 3.2 had such features. While promising, further patient-centred studies are needed to evaluate the effectiveness of such approaches.

Video recording was concerning to both patient and doctor participants in terms of knowing who had permission to access the video records and how one would acknowledge the use of video recordings. TELUS Babylon only audio-records consultations with the patient’s consent. None of the other applications I assessed provided such a feature. This continues to be an open design space where video recording could be valuable to keep accurate records of patients’ appointments and help to build trust with new doctors where they can learn more about a patient’s history. Yet, the privacy concerns are very real from the patient perspective in terms of unauthorized recording or sharing. Providing notice that an appointment being recorded or accessed by doctors in follow-up appointments might help patients be more aware of any potential issues with recordings.

3.6. Summary

In this chapter, I described the first study that is aimed to understand patients’ and doctors’ needs of using video conferencing for doctor appointments in their homes. I used a scenario-based interview method and conducted interviews with both doctors and patients to explore their thoughts on using app-based video calls and the user interface challenges that emerge. I found that social concerns exist in relation to establishment and maintenance of doctor-patient relationships. I learned of the value of a pre-location, such as a virtual waiting room, to place participants in prior to the start of a video appointment call. I saw challenges around patients showing parts of their body to the remote doctor, of which the camera work is different from contexts such as family or friends communication, and in working scenarios. Further, the study uncovers privacy challenges in terms of sensitive medical situations, patients’ identities, control of appointment access, and video recording.

Chapter 4.

Participatory Design with Patient Partners and Dr.'s Eye Prototype

This chapter presents a participatory design study and prototype design process. The participatory design study includes patients as partners participating in the system design process. I ran three sessions with patient partners to address the following research question:

- What design factors are important for designing video conferencing systems that can meet the needs of varying types of **body examinations** in the home setting?

The participatory design study was informed by the exploratory study in Chapter 3 to further narrow down the design space and investigate design factors to support body exams during doctor appointments over video. Four system features were generated through the participatory design study to guide the design of a video conferencing prototype, Dr.'s Eye. Based on these features, I created the prototype with an iterative design process. Details are described in this chapter.

4.1. Recruitment

To understand design needs, I employed a participatory design method (Spinuzzi, 2005; Sanders, Brandt and Binder, 2010) that involved patients, and a lesser extent, a doctor as our design partners. The aim of the participatory design study was to assist with the ideation of the video system and decision making in the refinement of the prototype. As the prototype system was mainly targeted on how to support patients being examined differently in their homes, the participatory design mainly recruited patients as design partners to understand how they might use the prototype in varying types of medical situations. Yet, a family physician was also invited as a counsellor to provide with professional advice on the creation of appointment scenarios, in terms of what medical situations could be conducted virtually, what types of exams would be involved, and what the doctor would want to see during the appointment. I recruited patient partners with the help of Reach BC, an organization aimed at connecting health researchers and patients in British Columbia. The recruitment information was posted on the Reach BC website and sent to their patient network through emails. A total of thirteen candidates signed up to participate in this project. I sent emails to all the candidates and asked four questions to help choose eligible participants:

1) Why are you interested in being a patient partner on this project?

2) What is your primary occupation and how long have you been in it?

3) We are looking for patient partners who have been a part of a doctor/patient appointment using a video call. Have you had such an experience? If so, please share some details.

4) Are there any other experiences/expertise you think you can contribute to this project?

These questions were asked for a few reasons. First, the prototype design could benefit from patient partners' previous video appointment experiences. They might be able to provide more practical feedback on what features might work or not work based on their individual situations and interactions over video. Second, their professional backgrounds could contribute to the study. Although they were not professional designers, their expertise might partially meet the needs of designing and help with our design process. Recruiting design partners with various backgrounds could also get a broader perspective on this topic. In addition, they were expected to show strong interests in our project and be willing to contribute design thoughts.

Candidates who did not reply, had no video appointment experiences, and gave very short responses were excluded from the study. They were also selected based on their range of experiences with virtual doctor appointments. Finally, I chose six (five female, one male) from thirteen candidates with the age range from 30 to 71 (AVG = 53, STD = 16). All had prior virtual doctor appointment experiences, either for the reason of chronic diseases or acute health issues. They had various backgrounds such as experience in healthcare research, product design, social services, and community volunteering. Details can be seen in Table 4.1 below.

Table 4.1 Patient Partners Enrolled in the Participatory Design

Patient Partner	Age	Gender	Video Appointment Experience	Other Experience/Expertise
P1	30	Female	physiotherapy, kinesiology, and with the family physician	Background in studying healthcare technologies
P2	52	Female	With the family physician	Computer professional
P3	53	Female	Occupational therapy, cardiology, and with the family physician	Volunteering experience
P4	41	Female	With the family physician	Working in social services
P5	68	Male	Cardiology, and with the family physician	Participated in other health research studies
P6	71	Female	With a respiratory specialist	Medical office assistant

4.2. Participatory Design Method

Each session was planned to last around ninety minutes. Considering the length of time needed for sharing thoughts, discussion and their availability for each session, patient partners were equally divided into two groups. Each group had a facilitator from our research team, who guided the group through three online co-design workshops. Groups used the online whiteboard Miro as a shared workspace.

4.2.1. Session 1: Identify research questions, goals, and hypotheses

In the first session, working with a research collaborator, we started with an orientation to help patient partners understand the research background, questions, and goals. Since design challenges have been identified in the previous interview study (Chapter 3) with patients and doctors, the primary purpose of this session is to have patient partners pitch in and learn about what obstacles exist in the use of current video conferencing systems for doctor appointments. They were asked to share their virtual health consultation experiences and what they thought were challenges during the video call in terms of interaction, communication, and any kinds of technical or socio-related issues. Sharing personal experiences could help patient partners get more engaged that they might have faced similar problems when video calling their doctors. Prompt questions were given on the Miro board (Figure 4.1), and patient partners could use stickies to share their thoughts. Questions included:

- Objective level: “What video appointments did you have?”, “What kind of exams were you trying to achieve in that appointment?”

- Reflective level: “What made it difficult/easy to achieve? Or, what was not as good / better than in-person appointments?”

In addition, they were encouraged to consider other possible medical situations where consulting with the doctor over video might be different from that in person. Such situations were also noted on their Miro board. For topics that patient partners did not cover, for example, exposing private body areas over video which never happened in their real life, we brought up the question and asked the panel to discuss potential challenges that might emerge during such virtual appointments.

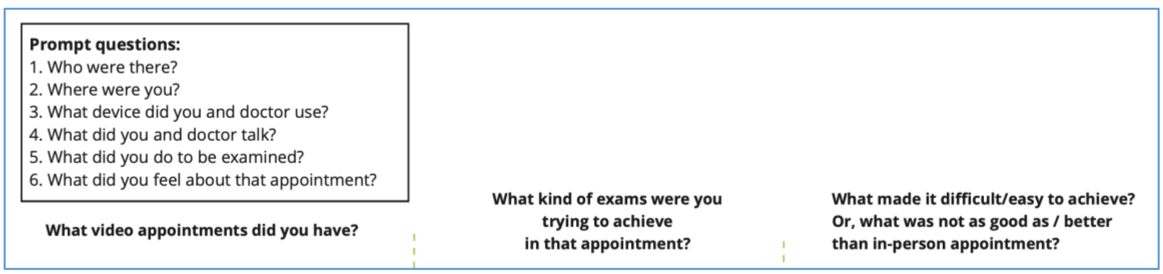

Figure 4.1 Participatory design session 1: learning about patient partners’ personal video appointment experiences.

After the workshop, we collected the sticky notes on Miro boards and selected what we believed were related to my research focus. For example, the notation “difficult to show which area of the foot was hurting via video” (P2) described the challenge of camera work in capturing patients’ bodies. Such notes were consistent with the findings from my prior exploratory study (Chapter 3). Some notes were beyond my research scope. For example, the message “having to report on my progress weekly helped keep me on track” (P3) was associated with long-term healthcare management; “Inability to touch my scalp for medical evidence” (P5) referred to remote sensing. My research is focused on real-time video conferences. Therefore, these notes were excluded from the analysis.

To avoid the research focus being too broad, we further narrowed down the context to be “during” the video appointment. Some design implications uncovered from the prior study (Chapter 3) were not incorporated, including accessibility issues, such as booking appointments, virtual waiting rooms, or screening patients’ situations that occurred before the appointment, and data access that came about after the appointment. As a result, we identified four main challenges in the use of video conferencing for doctor appointments:

- **Examine different body regions.** Showing one’s body part (e.g., throat, arm, leg) using a single device is difficult.
- **Perform body actions.** Capturing body movement (e.g., walking) is challenging.
- **Sensitive topics or exams.** Examining the body area that needs to remove clothes is embarrassing.
- **Privacy concerns.** Patients are worried about privacy exposure, such as showing their surrounding environment, the camera being controlled by others, or video recording, etc.

This informed that the design should focus on these perspectives. It also helped shape the tasks that patient partners would make use of in the following session.

4.2.2. Session 2: Generate Design Ideas

To support patients in developing specific and grounded ideas to address these challenges, we used the scenario-based design method, which was also used in the first study to understand challenges of existing video systems. Such scenarios could help patient partners be situated in specific situations and think about what technologies or interaction techniques might be helpful to resolve challenges that emerged in these situations. We partnered with a family physician with over thirty years of medical practice and developed realistic video doctor appointment scenarios. These scenarios were created with a similar approach from the first study. They should be able to present the challenges raised in Session 1. For example, examining different body regions were believed challenging using one’s smartphone. The created scenarios should cover typical issues in the use of the smartphone to capture body regions. After the scenario creation and selection, a total of four scenarios were chosen, which were largely inspired by scenarios from the exploratory in Chapter 3, including sore throat, hurt leg, itchy chest, and depression. Each scenario came with prompt questions specific to the type of challenge. Scenario descriptions and questions are given below.

1) **Sore Throat:** Anna made a virtual appointment for a sore throat. The doctor asked about her symptoms, then asked her to hold the phone and show her throat. Anna opened her mouth, laid her tongue down, and tried to shift the phone camera to capture her throat. She found that it was difficult to see the phone screen and know what she was showing the doctor.

   Questions: How could we design technologies to **help the patients see what is being captured**? What features could the technology have? What might it look like?

2) **Hurt Leg:** Anna fell and hurt her foot and leg. She was not sure if she should see a doctor in person. So, she decided to schedule a video appointment first. In the video call, she had to bend down, reach the phone to her right foot, and circle around. The doctor asked her to hold her foot with one hand and gently twist toes with the other hand. But she found it challenging to perform the action because she had to hold the phone simultaneously. She could not completely follow the doctor's instructions, since the doctor would generally do such exams in a face-to-face appointment. The doctor also failed to observe Anna walking around to see if there was a joint issue. Anna felt upset as she had to schedule another in-person appointment.

   Questions: How could we design technologies to **help the patient capture different body parts, help the doctor give instructions, or observe the patient making gestures**? What features could the technology have? What might it look like?

3) **Itchy Chest:** Anna felt itchy in her chest area and scheduled a video appointment. The doctor asked about her symptoms and wanted to check

out her chest. Anna felt embarrassed when taking her shirt off in a video call. She never did this before. She also thought it was strange to show and describe the itchy area via the camera, especially when she saw herself on the screen.

Questions: How could we design technologies to **reduce the feeling of embarrassment/discomfort when having private body parts examined**? What features could the technology have? What might it look like?

4) **Depression:** Anna has been taking medication for back pain for a few years. The chronic pain also leads to mild depression. She needs to see her doctor recurrently. Anna had to schedule video appointments with her doctor due to the pandemic. She occasionally misclicked buttons, which muted her voice or turned off the camera. Anna didn't realize it until she noticed that she did not receive a response from the doctor, which made her feel annoyed. Anna was not a fan of video appointments because they were unlike face-to-face appointments. The doctor was concerned about her situation, but it was uneasy to check her status by making appointments very often.

   Questions: How could we design technologies to **simplify the use of video conferencing systems, improve the feeling of care, and support status updates?** What features could the technology have? What might it look like?

In Session 2**,** patient partners were asked to come up with as many ideas as possible that they thought could solve the design problems in each of the above scenarios. To encourage patient partners to propose solutions, we specifically stated that they were not required to consider how to implement the technologies.

Patient partners recognized the design requirements for these scenarios. For scenario 1 *sore throat*, they identified the need for receiving visual feedback on what the doctor was seeing. Using a single device, such as a mobile phone, was inadequate. They proposed design ideas, for example, “having a program that allows it to be open on two devices at the same time, one with a camera and one as a monitor” (P5). This suggested a design where the **camera and monitor could be detached and separated**. For scenario 2 *hurt leg*, we were told that holding the camera to conduct such exams was uneasy. Instead, patients should "position their phone accordingly without having to hold it in the hand" (P2), for example, "on a stable surface/tripod and demonstrate what the doctor asks" (P4). This suggested a design where the **camera can be fixed and solitary** at a proper distance to capture patients' bodies or actions. For scenario 3 *itchy chest*, patient partners felt that the body images should not be linked to patients' identities. It was inappropriate to transmit camera images to the doctor when patients were not ready to show a particular area, so the **camera view could be hidden** during that time. They also suggested the system be able to "**blur out private body parts that are not necessary for the assessment**" (P6). For scenario 4 *depression*, in-person interactions such as eye contact or physical contact were considered essential in virtual visits as well. They hoped the system could allow the patient and doctor "to interact with each other and feel each other's physical interactions" (P1). This suggested the design to embody the doctor during video visits similar to face-to-face appointments.

4.2.3. Session 3: Refine Designs

To delineate the form of my final prototype, in Session 3, we proposed three potential products. We conducted a broad search on video cameras or video conference systems (prior to the session), adopted ideas from the patient partners in session 2, and proposed three potential products to participants in the sessions. They combined extra features to meet the requirements identified by the group in Session 2. These three solutions are more focused on the use of cameras to help examine patients. As a result, we did not include features especially for improving eye contact. These products included:

- **A handheld camera and a monitor:** Patients can see what the camera is showing from the display. (Figure 4.2)
- **A drone camera and a monitor:** The drone can be controlled to capture patients. (Figure 4.3)
- **A telepresence robot:** The doctor can control the robot to examine a patient's body. (Figure 4.4)

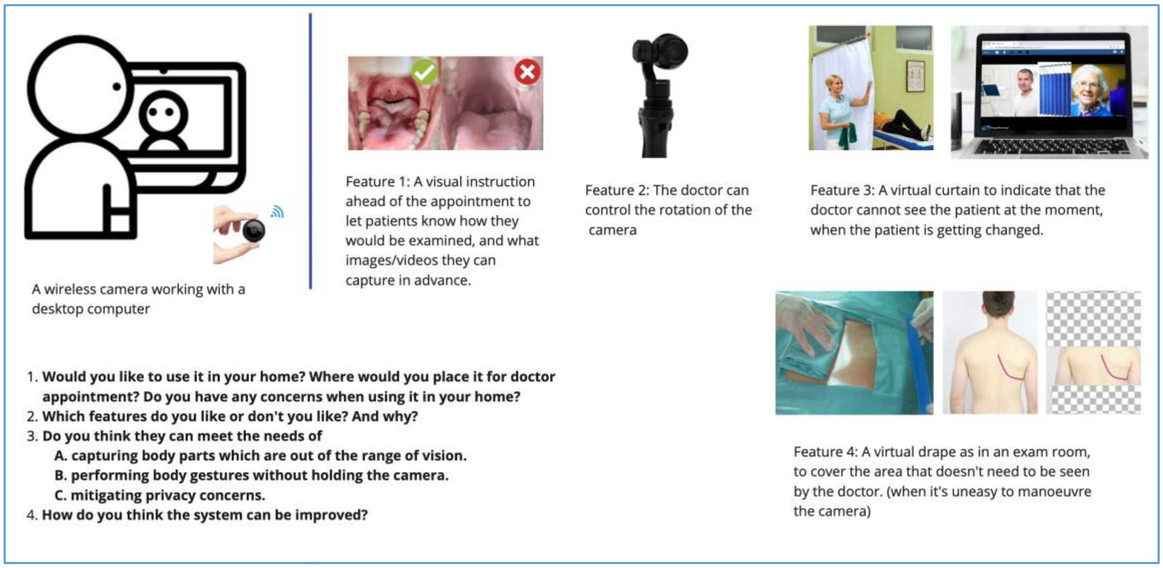

Figure 4.2 Proposed design solution 1: a handheld camera and a monitor.

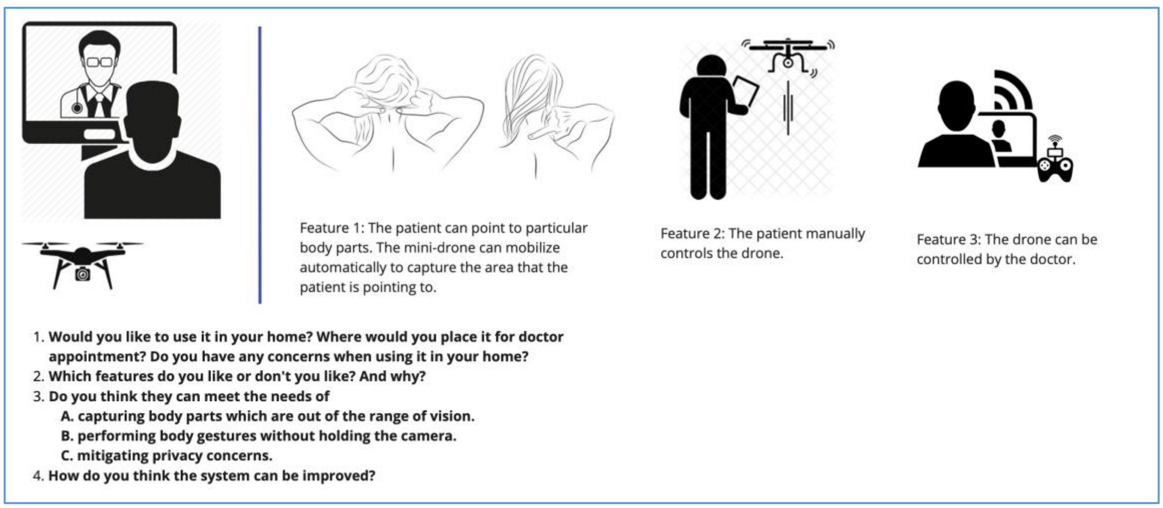

Figure 4.3 Proposed design solution 2: a drone camera and a monitor

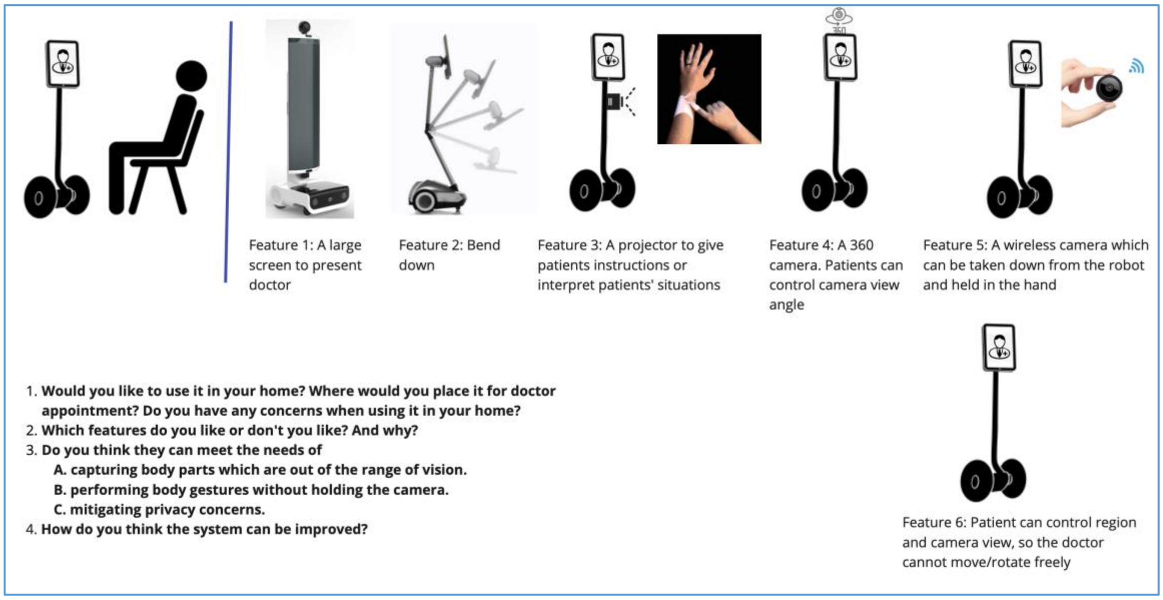

Figure 4.4 Proposed design solution 3: a telepresence robot

Patient partners were given the same scenarios as in Session 2 and asked to reflect on the potential benefits and drawbacks of using these three different systems for each scenario. Figure 4.5 and Figure 4.6 show feedback from patient partners in Session 3. They identified that the drone and telepresence robot could free their hands when capturing patients' bodies. Yet, the most significant problem with them was their mobility. With the drone, they were concerned about the difficulty of controlling the drone flying in the room either by themselves or the doctor. Dealing with the drone and communicating with the doctor simultaneously might be too much for patients. Patients might also get hurt by its propellers if the device or system was not reliable. Further, flying the drone was confined by the room space, which could be too limited to move around. With the telepresence robot, they felt the robot was too bulky to be used for video conferencing with the doctor. It was also limited by the room space like the drone. The floor might need to be cleared to support it moving around. In addition, they found the idea of a doctor moving the robot around in the patient's room to be privacy intrusive. In summary, they were not in favor of a video camera with uncontrolled mobile capability on their own. In comparison, they felt Solution 1 was acceptable where they could hold a camera with the autonomy of controlling its location. Based on these findings, we decided to exclude the last two solutions and implement my system using a wireless camera and a display.

Figure 4.5 Miro board for session 3. Comments were generated by patient partners from group 1.

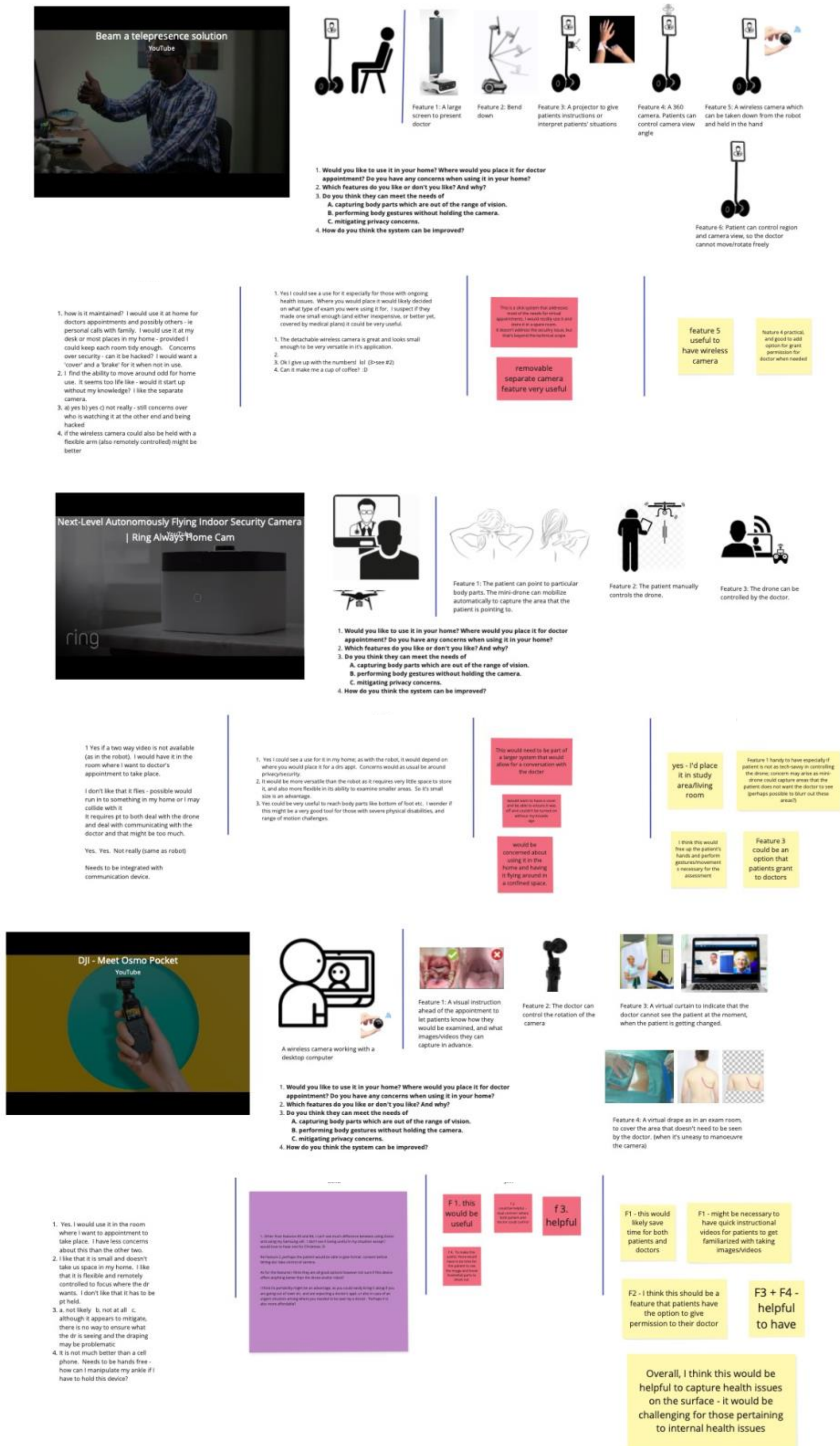

Figure 4.6 Miro board for session 3. Comments were generated by patient partners from group 2.

4.2.4. Design Characteristics and Interactivity

Based on the design requirements we uncovered in the participatory design study, we proposed four main features for a system to support various forms of visual doctor inspections:

1) **Decouple camera and display:** The patient can capture a view of their body using an external camera and see the video stream on the phone. This helps patients always have visual feedback on the display when moving the camera around, for example, when shooting body parts that are out of their direct view (e.g., throat, back).

2) **Free capturing:** The patient can put the camera on a table or attach it to any other surfaces, like a wall, without holding the camera in their hands. This could be helpful when it is not convenient for patients to hold the camera in their hand, for example, when performing body movements that occupy both hands or when the user must be at a specific distance from the camera to see an entire body region.

3) **Hide my camera view:** When 'hide my camera view' mode is on, the video stream sent to the doctor is disabled. Only patients see what the camera is currently showing. This enables patients to align the camera into a proper pose until they are ready to stream images to the doctor.

4) **Virtual cover:** By selecting a part of the image in the camera view, patients can limit the area that the doctor can see. A slider can adjust the rest of the camera view from transparent to completely opaque. An algorithm ensures that other body parts are kept hidden even when the camera moves. This approach aims to protect patients' privacy in that they can limit the view to show the doctor only the parts that are truly necessary for assessment.

4.3. Prototype Design of Dr.'s Eye

I created the prototype through an iterative design process that included brainstorming, hand sketching, and creating a variety of low-fidelity prototypes, from a folded paper box to a draft 3D model. The design implementation was widely informed by the technological probe approach (Hutchinson *et al.*, 2003). The prototype, named Dr.'s Eye, contains two components: 1) an external camera embedded in a 3D-printed enclosure (Figure 4.8), and 2) software running on a mobile phone that streams video between the patient and doctor (Figure 4.10).

4.3.1. External Camera

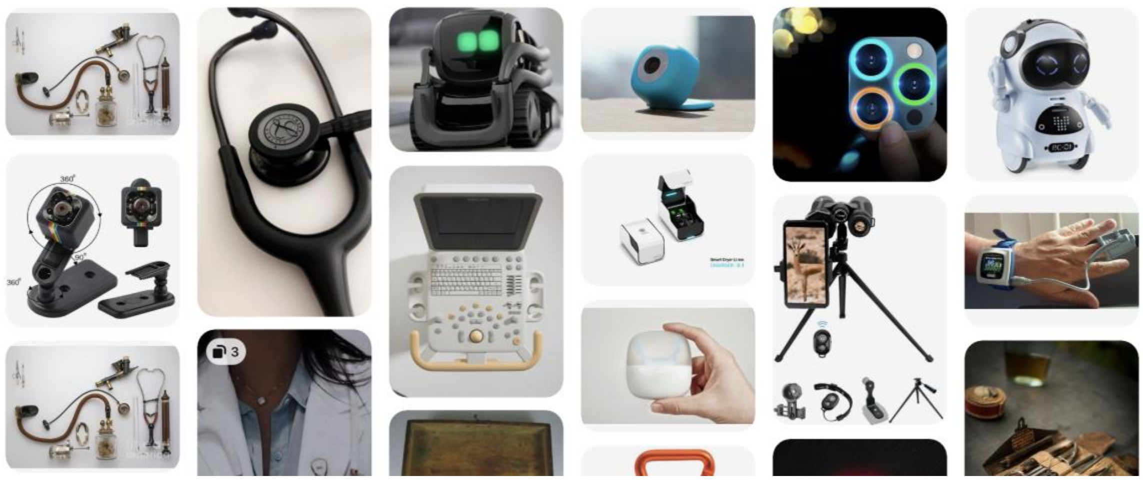

Figure 4.7 Pinterest pins for inspiration and discussion

With an aim to build people's comfort and trust in the artifact, our design team created a Pinterest artboard (Figure 4.7) to collect numerous form design pins in the medical equipment field as inspirations for us to get a sense of how to present a professional but welcoming feel. After several rounds of discussion and design iteration, I decided to embrace simplicity and warmth as qualities that drive the secondary design decisions.

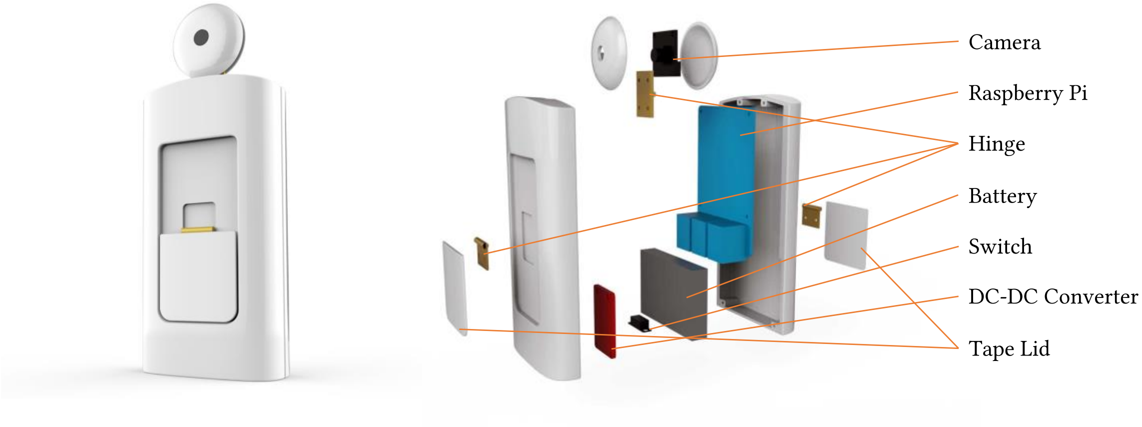

Figure 4.8 Left: The prototype (as an external camera) used together with a mobile phone (as a display), designed to assist patients in showing regions of their body in a virtual appointment. Right: Electronic components embedded in the prototype form, including a Raspberry Pi microcontroller and a compact camera module that allow patients to place and adjust its angle during the call.

Figure 4.8 shows the final design of the external camera and its enclosure. Inspired by the small disc-shaped resonator of a stethoscope, I designed a rounded form to highlight the camera's position. I adopted a hinge to connect the body and the camera component. Users can rotate the hinge to get the desired camera orientation. I also designed a form enclosure to enhance its flexibility. The base of Dr.'s Eye is flat so users can place it on the table surface. I intentionally added heavy-duty reusable tape on two sides of the form enclosure, so users can also stick Dr.'s Eye onto vertical surfaces, such as a wall (Figure 4.9). In addition, the enclosure was designed to be rounded to fit the size of users' palms. The finalized form enclosure was designed with a slight anthropomorphic look to create a sense of accompaniment and to signal that the video stream would be delivered to a professional party in an appropriate context (DiSalvo and Gemperle, 2003). I produced a set of Dr.'s Eye prototypes through 3D-printing to the final assembly. I used white-colored PLA material to print the form enclosure as it can offer minimalist aesthetics and endurance for the study.

Figure 4.9 ***Left***: **reusable tape on a lid, which connects the form enclosure through a hinge. The lid can be turned over to expose or hide the tape.** ***Middle***: **the external camera attached to the wall with the back side tape.** ***Right***: **the external camera attached to the mobile phone with the front side tape.**

4.3.2. Mobile Phone User Interface

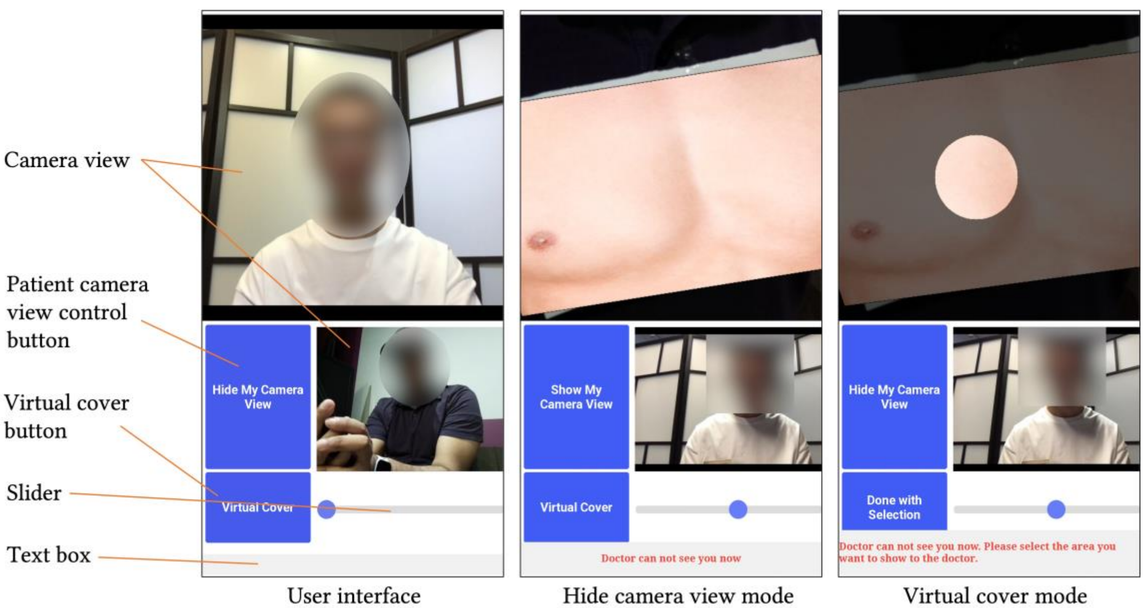

Figure 4.10 System interface on the patient's mobile phone. ***Left***: **Default page when the video call is initiated.** ***Middle***: **Video stream to the doctor is disabled when hide camera view mode is on.** ***Right***: **Virtual cover mode is on. Patients select a circle area on the camera view. Only the highlighted area is sent to the doctor.**

I used the web framework Flask and OpenCV to implement the video system. The design uses a mobile phone with a 6-inch screen size to connect to the doctor who interacts with the system on a webpage. The user interface includes two camera views, a virtual cover button, a camera view control button, a slider, and a text box (Figure 4.10 left). Camera views come from Dr.'s Eye on the patient's side and a laptop camera on the doctor's side.

Patients can tap on the small camera view to switch which view they want to be shown larger at the top. When patients click the *Hide My Camera View* button, a message pops up at the bottom, saying "Doctor cannot see you now", which means the doctor cannot see the patient's video stream until they click the *Show My Camera View* button (Figure 4.10 middle).

When patients click the *Virtual Cover* button, their video stream to the doctor is automatically disabled. The pop-up message is "Doctor cannot see you now. Please select the area you want to show to the doctor". Users then can draw a circle (press down, move, and release) on their camera view to select an area they want to show to the doctor. After making the selection, they can click the *Done with Selection* button (Figure 4.10 right). The doctor will then only see the selected body area. The circle follows the body region when the patients move the camera, to ensure that the doctor will not see other areas. Patients can use the slider to change the level of desired transparency of the unselected body area.

The doctor's webpage includes two camera views: a larger view of the patient, and a smaller one of the doctor.

4.4. Summary

In this chapter, I described a participatory design study that involved six patient partners in the design process. Three design sessions were conducted including identifying research questions and goals, generating design ideas, and refining designs. Four essential design factors were proposed to guide further prototyping, including *Decouple camera and display*, *Free capturing*, *Hiding my camera view*, and *Virtual cover*. Then, I conducted an iterative design process and created the video conferencing prototype, Dr.'s Eye, which contains an external camera and a novel user interface to support patients video calling their doctor. The Dr.'s Eye was created to help understand how patients use different features when video conferencing with a doctor in a home setting.

Chapter 5.

Evaluation of Dr.'s Eye in Home Settings

This chapter presents a qualitative study to explore how patients use the video conferencing prototype, Dr.'s Eye, in various medical situations. I conducted scenario-based semi-structured interviews with patient participants where they attended mock video doctor appointments and were asked about the benefits and challenges of using different features to support these varying scenarios. The study explores the following research questions:

1) How will patients use a video conferencing system that is specially designed to support body examinations during doctor appointments?

2) What are the benefits and challenges when using the system?

The study contributes an empirical understanding of conducting varying types of exams over video in a home setting. It informs our understanding of design factors that should be valued in future system design to overcome interaction issues for both technical and social-technical aspects during video doctor appointments.

5.1. Participants

I invited 18 participants to participate in the lab study. They were all adults between the age of 21-75 (AVG = 41, SD = 16), eleven males and seven females. Participants were recruited via several strategies. I sent emails to university mail lists; posted the ad on social media platforms; and, posted posters on university and local library billboards. I also posted the study on the Reach BC, which sent recruiting emails to their patient network. I wanted the participants to cover a broad age group. Candidates were required to be familiar with the use of smartphones and video chat.

5.2. Study Protocol

Each person participated individually in the study. First, I conducted a brief background inquiry to learn about participants' past experiences with family doctors in-person or over video. The inquiry was designed to help participants recall what situations they went to the doctor for and how their appointment experience improved or deteriorated with the use of video conferencing. Their past experiences might also resonate with scenarios given to participants to help create a stronger sense of engagement. Participants were asked, for example, "Have you ever had video doctor appointments? Do you remember what the reasons were you needed to see a doctor?", "Is there any reason you did not try video appointments?"

Next, an exploratory study was conducted to investigate how the new features of my video system could make a difference, in comparison to using current video conferencing apps or seeing the doctor in person. This required my study to be able to cover a range of scenarios that could potentially happen in existing or future doctor-patient encounters. I also did not want to infringe on patients' privacy since they might consider their appointments to be confidential. I was inspired by the scenario-based design and user enactment methods (Carroll, 2000; Odom *et al.*, 2012), which were generally applied to probe the design of artifacts with potential ways of usage in a lab setting. To understand the use of my video system in varying contexts, I designed a list of scenarios where a range of medical situations were presented. Participants were asked to enact a patient as described in each scenario using the video system. Each participant was asked to go through all the scenarios using the system.

I designed five scenarios representing varying types of situations where patients might use camera work differently when seeing a doctor. To design appropriate scenarios, I used ideas from the exploratory study in Chapter 3 and the participatory design study in Chapter 4. A list of medical situations were brainstormed based on how different features of the system could be applied when patients describe and present their symptoms over video. For example, decoupling the camera and display can help a patient see what is being captured by the camera when a body part to be shown is out of their sight. Such body parts could be the inside of one's mouth, their neck, or back. Situations related to the mouth could involve a sore throat, swollen gums, or mouth sores. Then, I selected four scenarios which I believe could highlight the differences between my system and current video apps. I also inserted a situation which needed no camera work to begin with. The purpose was to help participants get acquainted with the process. It also worked as a comparison with other scenarios so that participants could feel changes in using the system. Afterward, I iterated on the scripts for these scenarios and consulted with a doctor to ensure that the narrative corresponds to what happens in actual doctor appointments. Brief descriptions of the scenarios follow below and in Table 5.1, listing what features I expected to examine for each scenario.

1) **Diarrhea**: The patient had diarrhea for a few days and consulted the doctor over video. The patient described their symptoms to the doctor. Then, the doctor prescribed a lab test and medication.

2) **Sore throat**: The patient had a sore throat and described their symptoms during the video call. The doctor asked the patient to open their mouth and say ‘Ahhh’ to expose the tonsils. Meanwhile, the patient held the camera to capture the tonsils clearly.

3) **Chronic pain in the knee**: The patient saw their doctor regularly for chronic arthritis on their knees. The patient was asked to lift and hold their thigh with two hands, and to extend the lower leg slowly to see if the pain was relieved. Then, the doctor asked the patient to show their ankle and press on it to check if it was swollen.

4) **Chest acne**: The patient had bumps on the skin of their chest. The patient was asked to show their chest to the camera. The patient needed to remove their top to show the area.

5) **Post-surgery recovery**: The patient had surgery due to a lumbar disc protrusion. The patient video-called the doctor as scheduled to check on the recovery of the surgical site in their lower back. The patient was asked to pull down their pants to expose the surgical area and show to the doctor.

Table 5.1 Features to be explored in the scenarios

Scenario	Decouple camera and display	Free capturing	Hide camera view	Virtual cover
1. Diarrhea				
2. Sore throat	✓	✓		
3. Chronic pain in the knee	✓	✓		
4. Chest acne	✓		✓	✓
5. Post-surgery recovery	✓	✓	✓	✓

I took several measures to balance potential ethical risks with the realism of the video appointment scenarios. First, I did not ask participants to actually take off their clothes and expose their body parts. Otherwise, this would create significant ethical concerns. Instead, I printed fiducial markers and stuck them to participants' clothes. When the marker was within the camera view, the algorithm would recognize the marker and replace it with a generic picture of the corresponding part of the human body. Thus, the participant would see a camera view on the phone screen that was like their body being exposed. The purpose was to help participants experience a situation that was like them actually having a video appointment with a doctor. For example, in the *chest acne* scenario, participants were asked to put the camera close to the marker area. They would see a photo of a chest overlaid on the display. They could imagine how they would feel and what they would do in such contexts. I selected ten pictures for each body area, including chest and lower back, five from male and five from female bodies. Before the 4th and 5th scenario, participants were asked to pick the one they thought was closest to their own body. I explained to participants that the aim was to help create a feeling of realism, but that pictures might not represent their bodies exactly. The interviewer acted as a doctor when participants role-played in these scenarios.

Figure 5.1 Study room setting. Participants sit in the chair. The interviewer sits behind the divider during mock appointments and returns to participants' space during the interview.

Participants were situated in a mock home space in our research lab that contained couches, chairs, television, coffee table, etc. (Figure 5.1). For each scenario, participants were first given enough time to read the script of the scenario and familiarize themselves with it. Rather than give them specific instructions on how they should use different features, they were told to go through the appointment in the way they were comfortable with. A room divider was set up to separate the interviewer and participant so they could not see each other during the mock appointment. The doctor (interviewer) saw participants using a laptop with a 13-inch screen and a camera. The benefit of playing two roles was that the interviewer would observe participants clearly from the first-person view of the doctor. They were able to raise questions when they noticed unusual reactions from participants. After each scenario, the interviewer returned to the mock home space and interviewed participants.

Example interview questions included, "*How do you feel about using the system for this situation?*", "*Is this something you could see working over a video call? Why or why not?*", "*How do you think the system can be improved?*" I also asked participants to use the phone camera only for the scenarios when interviewing them. The purpose was to motivate participants to come up with more details of the benefits or concerns of using my system compared to current commercial apps. Additionally, I asked questions regarding specific features. For example, in the *chest acne* scenario, I asked questions like, "*How do you feel about using the virtual cover feature in the video call?*", "*How is it different from using general video systems or in-person visits?*" I also asked questions based on my observations. Questions included, "*I noticed you did…, could you explain why you used it that way?*" After all the scenarios were discussed, I asked participants if there were other situations where the system could be helpful or challenging. The aim was to explore a wider range of contexts.

5.3. Data Collection and Analysis

The data collected from the study included audio recordings of the interview, video recordings of participants' behaviors in each scenario, and recordings of the doctor actor's (interviewer's) screen. Audio recordings were transcribed and coded by two researchers independently. We applied open, axial, and selective coding process to code the data. For example, axial codes like "position display" or "hold two devices" were created, representing challenges of participants operating the devices to capture their body in different scenarios. Then, the two coders discussed the codes, selected those we believed were novel compared to prior work, and created three high-level themes. These themes included *benefits and challenges in operating decoupled camera and display*, *camera coordination needs between doctor and patient*, and *patients' perceptions on viewing and sharing their own video streams*. I describe these themes in the following section. I present the findings with quotes from participants as evidence. Their quotes are listed as P#.

5.4. Findings

The findings provide insights on how participants used the video conferencing system prototype in various simulated scenarios, as well as their values and needs behind their usage or non-usage of the designed system features. In this section, I describe the benefits and challenges that participants had when operating the separate camera and display at the same time. With an uncoupled camera and display, I present doctor and patients' coordination needs when performing camera work. I then describe participants' perceptions on viewing and sharing their video streams.

5.4.1. Benefits and Challenges in Operating Decoupled Camera and Display

Uncoupling the camera from the phone display brings flexibility for capturing various body regions, while still enabling patients to see what is being shown to the doctor on the phone. Yet, this also raises challenges in maneuvering two devices instead of one during a doctor appointment context. In this section, I present participants' perceptions of using the system in various situations and what they believed were the benefits of as well as challenges for a separated camera and display.

Allowing Freedom to Capture Anywhere

Participants recognized the benefits of having the camera separate from the display in the situations where they needed to capture a body region that was out of the range of their vision or where they needed to place the camera away from them to show a view at an appropriate distance. In both cases, a separated display allowed them to view the camera's feedback, when a coupled camera and display would have been hard to see. Participants shared the difficulties with traditional video cameras to see what the camera was recording. For example, in the *sore throat* and *post-surgery recovery* scenarios where throat and lower back were examined, participants said it could be difficult to use the mobile phone camera to capture the area and simultaneously see what was showing on the screen, because the phone would be either directly in front of the mouth, under the chin, or behind one's back. This places it beyond participants' capability to easily see. In comparison, the uncoupled camera-display design would allow patients to place the phone display in front of them and to move the unassociated camera around.

> "I think if I brought a phone closer, then I won't be able to see the screen. … So now, since it was separate, I could bring it as close as needed." –P5

The phone screen can also be out of patients' sight when the phone camera is set far from themselves to capture more information (e.g., full-body image, performing movements). For example, participants brought up the issue in the *chronic pain* scenario that the phone might be placed on the floor at an angle where they could not see the display when walking forward or backward. It might also be too far away to see the phone image clearly. Yet, participants said that the separate camera could just be placed on its own, and they could still hold the phone in their hand to get a better view. As a comparison, this would be hard to do with traditional video technology.

> "I think that it's very helpful, because you only use phone is very limited, you cannot just put the phone too far away from you." –P11

Patients' Challenges in Positioning and Operating Camera and Display

Despite the benefits with uncoupling the camera and display, participants found challenges when holding devices by hand, coordinating two devices simultaneously, and getting used to viewing and talking to different devices. The exams over video could be highly mobile so that patients might need to move their body in various ways, while the display was expected to be mobile as well to ensure patients could provide a comfortable viewing angle. Properly holding the display for it to be viewable by patients was challenging sometimes. For example, in the *sore throat* scenario, participants held the camera in one hand close to their mouth. Meanwhile, they had to hold the phone in the other hand to see what is being captured by the camera (Figure 5.2). The situation worsened when they raised their head up to get better lighting from the ceiling since it was too dark in their throat to have good visibility. Thus, the phone had to be lifted higher, which was laborious for patients to coordinate with both devices.

> "I had a hard time focusing or rather keeping the display up. So I had to basically prop the phone up, … I was also looking at the feedback to assure what you (the doctor) can see." –p1

Figure 5.2 Hold two devices at the same time in the *sore throat* scenario.

This issue also happened in other situations where it was not always easy for them to arrive at a comfortable view. I observed some participants lay the phone on the table and lean their body forward to look at the screen; some used a plant pot that was placed on the table for decoration. Some participants raised the concern of finding a way to put the display in a fixed position to see it comfortably.

> "I wanted to see what the doctor is seeing, which means that I need to take a look at the display, which means I need to fix the display somewhere. Now the problem was that since I had to actually work with both hands that I needed to put the camera somewhere so I felt a little bit uncomfortable." –P3

In addition, participants also unintentionally misaligned the camera view and the phone display. In a general video chat solely using the mobile phone, the disparity between the front camera and their view direction to the display was minor, so they generally felt they were looking at the remote person on the display. In contrast, participants tended to place the phone face-up on the table but placed the camera standing beside the phone, i.e., the devices were oriented orthogonally to each other. In this case, they struggled with where to look at in the video call with the doctor.

> "One problem I'm facing now is, do I look into the camera or do I look at the screen? So like I'm switching between both, but I think most of the time, I start looking at the screen and not necessarily at the camera." –P5

In exams that involve fewer movements, operating two devices simultaneously can still be difficult as it increases the burden of usage. I was told by participants that they were not used to working with two devices simultaneously for a video call. In their prior experience, they were familiar with aligning a single phone to adjust the camera view. In contrast, in the scenarios I investigated, they had to align the camera and hold the phone steady to see what the camera was showing.

I also observed interesting behaviors of some participants when using my multi-device system. First, they confused the camera and phone in trying to capture something. For example, when they were supposed to adjust the camera position or angle, their phone hand followed the camera hand involuntarily in performing the same action, or the phone hand shifted rather than the camera hand. Their upper limbs also appeared to become stiff and uncoordinated. Holding two devices seemed more of a struggle than holding a single device.

> "I need to look at both and I have to keep switching within them. Since I'm holding both, then, I'm kind of confused between the positions. So, let's say if I want to adjust this (camera) and I start adjusting this (phone) instead, and then, if I adjust this (camera) and subconsciously I have just moved it (phone) without like looking at it." –P5

Thus, participants were generally in favor of fixing the camera somewhere to help capture their body, e.g., by placing the camera on the table, without requiring a holder to support it. Patients might also need to be able to stick the camera onto the wall so that they would not need extra help from someone else.

> "You can stick it to the wall or maybe stick it to the TV or something. And then do like the stretching in front of it. Without someone holding the phone, they can do that." –P8

Figure 5.3 In the *chronic pain* scenario, the participant positioned his ankle within the camera view instead of positioning the camera.

Second, I noticed that the positioning of the camera might be related to the camera work required in varying scenarios. In the *chronic pain* scenario where the patient was asked to stretch their leg and show their ankle, I expected participants might place the camera on the floor to capture their leg or ankle and then do the actions. Yet, most of participants twisted their body and leaned back in the chair to let their legs be situated within the view of the camera standing on the table (Figure 5.3). The only adjustment with the camera was that they tilted the head lower or adapted the orientation toward themselves. Similarly, in the *post-surgery recovery* scenario, I expected participants might stick the camera on a vertical surface, like the wall or along the TV screen, and then stand in front of the camera to show their back to the doctor. Yet, at the beginning, they generally grasped the camera in their hand and curled their arm behind the back to try to capture that area of their body. Then, they typically realized that it was difficult to capture their back area that needed to be seen by the doctor.

Therefore, they chose to stick the camera to the wall instead. I assumed that the reason might be that participants tended to use the least effort to pose the camera. In such scenarios, bending down to place the camera on the floor might take more energy than lifting their leg; similarly placing the camera in a stationary position, holding the phone and moving themselves within the camera view might take more energy than moving the camera to show their back. Thus, I asked participants why they reacted in this way.

> "So, I mean, you could do this, you could do this too. Whatever you feel more comfortable with that just came naturally to me, because I have this sofa and I could do this." –P12

> "I never thought about putting it on the ground, … but I mean yeah, that's also another idea too actually… because we're stretching and then it just seems so normal… I feel very comfortable working with it to do like this." –P16

Although several participants realized that they could use the front tape to attach the phone to the camera sitting on the table, they felt that it was not intuitive to use the camera in this way as the combination of camera and phone was too bulky to easily hold it in their hands. This resonated with other participants who desired a futuristic design where the camera size would be smaller so that it can be easily taken down off the phone or mounted back on it depending on the current need of the camera work. As an example, they could have the camera attached to the phone when talking to the doctor like a normal video call, but could take it off when needing to show specific body regions.

5.4.2. Camera Coordination Needs between Doctor and Patient

In this section, I present coordination challenges and concerns behind camera control distribution.

Lack of Communication and Awareness about Doctor's View

In video chat examinations, camera coordination is often needed between the doctor and patient so that the doctor can instruct patients to show enough information for diagnosis. When asked about challenges, participants talked about their concerns on whether the image quality was good enough for an accurate diagnosis, and whether they could capture the correct regions. The image quality could be affected by the lighting, image clarity, or camera angle. Participants doubted if the camera was able to show the details of their body as in the clinic, which led to a lack of trustworthiness with the video conference. Further, although the lighting issue has been raised broadly in prior research, especially in teledermatology (Lee and English, 2018), where poor lighting showed skin color imprecisely which then led to misdiagnosis, it could be critical in general video doctor appointment contexts as well.

In my study, the issue refers to the fact that illumination is quite limited for certain medical situations. For example, in the *sore throat* scenario, participants had to turn toward the ceiling lights to get sufficient light into their mouth. They mentioned that they might have to do something similar in their homes, finding an extra light source to help illuminate the inner mouth. Thus, it could be tricky to conduct such exams without special equipment like the handheld light that doctors usually have in the clinic. Similarly, like P15 mentioned in the *post-surgery recovery* scenario, the lighting condition would be poor when participants fixed the camera on the wall and they stood close to the wall to capture their back, which exactly blocked the light needed to illuminate the image.

> "It was really awkward. I thought maybe the doctor cannot see the whole thing, and it took me a while to play with the cell phone and the camera, and to figure out the lighting, the best angle for it. It was very hard for me to do so." –P15

This suggested that for video doctor appointments the camera may need extra lighting to help capture different body parts. Participants advised that a light akin to the phone flashlight could be installed alongside the camera lens.

Participants also talked about the lack of communication about what doctors need to see, and the need for clear instructions from doctors. Specifically, they were not aware of what a 'right' location to place the camera was, in terms of where to place it, which direction to orient it, and how far away to place the camera.

> "One of the problems that I had, when the doctor was instructing me, when they couldn't see some spot and I needed to move it in a way for them to see it. I couldn't get the guidance that clear. Okay, should I move left? Right? should I go in or out? Or like, how should I go?" –P3

Device feedback could help build communication and awareness about how to move the camera. Participants provided potential examples of the feedback. It could be a visual sign on the display, as studied in prior research, e.g., in visual guidance for physiotherapy (Tang *et al.*, 2015). It also could be audio feedback or a combination of cues, as P1 suggested, "*when I bring it closer, maybe a target area is selected. So that's when it makes a beep sound that shows me a red circle*".

However, some participants said that they did not need to see details on their display. They believed that only the doctor should have good visibility of their body. The role of patients was to provide the doctor with what they wanted to see, which was similar to a clinic context, where they did not have to see their own body when they were being examined.

> "You don't need some details (of your body). You just (need to) know the doctor has seen you. You only (need to) know what you need to provide to the doctors." –P11

Concerns behind Distributing Camera Control to the Doctor

To improve the camera coordination between doctor and patient, distributing some camera controls to doctors could help resolve the communication challenges, e.g., letting the doctor pan or tilt the camera view. Many participants showed their willingness to have doctors more involved in their camera controls, given doctors' expertise or patients' limited mobility. Participants said that it was the doctor who was responsible for coordinating work in their clinic. Patients generally complied with what the doctor asked them to do. In a video appointment context, patients needed to take more responsibility to help the doctor get proper views of their body. Yet, they were reluctant to spend extra effort. Thus, granting camera control to the doctor could help reduce the workload as they would not have to conduct all of the camera work by themselves. This was especially helpful when patients had limited mobility. As P10 told us, "*I think if somebody's in that much pain, where they are immobilized or not able to put a camera somewhere, they would likely have someone there to help them*." As a result, participants saw the benefits of handing over the camera control to the doctor, so that the coordination work around how they should precisely position the camera could be reduced.

Yet, challenges remain in deciding what types of control patients would like the doctor to have and how much control they are comfortable with handing over to doctor. The challenges mainly came from security and privacy concerns when sharing camera control and granting camera access. Some participants felt that it was appropriate for the doctor to make minor adjustments to the camera. This included zooming in or out, rotating the camera lens, taking a picture, or controlling the light. Such camera control could be initiated when patients had already roughly oriented the camera to the area that needed to be viewed by the doctor. For example, in the *sore throat* scenario, holding the camera in front of the mouth was effortless. In contrast, subtle camera adjustments were usually needed to get the best orientation for viewing the tonsils, which might take substantial coordination work between the patient and doctor. Participants were fine with handing over camera zooming or rotations so they would not have to worry so much about showing the correct area. Such camera control could also help when patients placed the camera at a distance, e.g., to perform whole-body movements, where they could not easily adjust the camera (Figure 5.4). In this case, the camera's field of view might be limited to capturing what the doctor wanted to see, especially when patients needed to move around. Letting doctors adjust the camera view to capture specific areas during patients' movements could help patients concentrate on the task in these scenarios.

> "Well, that's where I think the doctor would want to be able to control the viewpoint and adjust it. Because first of all, if I'm gonna start walking, I don't know what the camera's going to see. Right? As I'm walking, my feet might be out of the camera view. Whereas the doctor could adjust it to look down more, to see how my feet are doing, or up more to see how my hips are doing." –P17

> "If the doctor can control the cameras so that I don't have to do two things at the same time. One, hold the camera pointing towards certain area; two, hold a cell phone and have to walk around." –P14

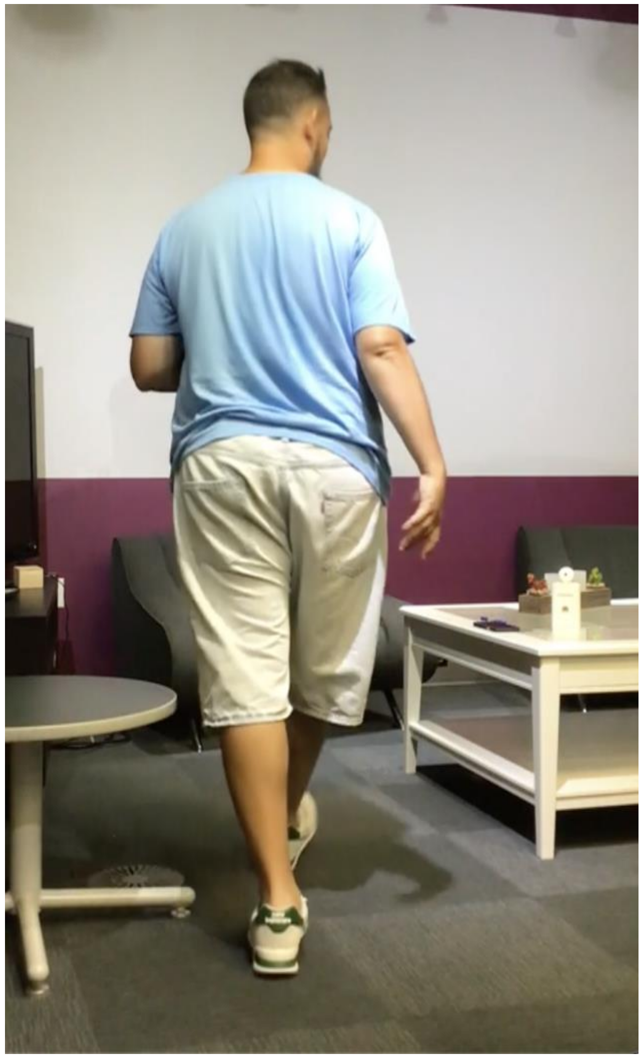

Figure 5.4 The participant placed the camera on the table when showing his gait to the doctor, meanwhile holding the mobile phone in his hand to see the camera view.

I found that the level of comfortableness with handing over camera control was related to a trusting relationship with their doctor. Participants with a good trusting relationship with their doctors were less concerned about letting the doctor take more control of the camera, similar to the access and power that doctors often had in clinical settings during in-person appointments (e.g., P4, P14). Yet, for patients who have not built relationships with their doctors, it could become a concern that unlimited camera control would allow the doctor to see their home space. Video chat can capture patients' personal information from their background, as P10 described, like "*inviting people into your room*". Such information, like their "*favorite movie poster on the wall*", was often not shared when consultations were conducted in the clinical space.

Thus, participants preferred that the doctor focus the camera view on their body only, but not elsewhere. This suggests a design space where the camera could be rotated or zoomed within limits when being remotely controlled by the doctor. Meanwhile, participants hoped they were able to manage when the doctor had the camera access and to supervise what the doctor was looking at after giving over the control, to assure that the doctor was not looking at something they deemed inappropriate. As P10 said, "*it would make the patient feel like they're in control of their own privacy.*"

> "Well, if I could see the picture of myself, like what exactly is he zooming into? Like what exactly does he see? I think that be good for the patient." –P15

Participants also raised concerns about trusting the system about access to the camera. Once the camera was capable of being remotely controlled, there could be the risk of being accessed outside of the appointment time, or even controlled by third parties. They expected the control to be properly revoked after completing the video call.

> "I'm using the device exactly at that point of time only. And I would expect that after the call is done, they wouldn't have control over it. So I'm okay with giving control over during the call, but not like, you know, before or after or something. So, maybe I might start thinking that, this device is only for specifically, for doctors' appointment. So, if this was a general purpose webcam, I would think twice if it can be controlled by someone else definitely." –P5

Participants also wished to have a physical cover design for the camera on my prototype to avoid it being accessed without awareness, as mentioned by P17, "*you never know if somebody can hack in and start viewing things without your permission*." Such physical components are simple but can make participants feel to have more control over the device and reassure their privacy is protected after revoking the camera access.

5.4.3. Patients' Perceptions on Viewing and Sharing Their Own Video Streams

When transitioning from in-person exams in a clinical space to video chat exams in a home space, the examining process and environment may change, and patient participants reported on feeling uncomfortable doing things that they were not used to during regular exams. Participants felt uncomfortable seeing and exposing their private body regions in the video call. Only showing what was necessary to examine was appreciated by participants, while the view feedback needed to be carefully designed.

Patients' Perceptions on Viewing Themselves on the Display

We learned that viewing a video stream of oneself during medical examinations can make patients feel uncomfortable, as it may raise self-image concerns and is different from patients' traditional experience with in-person exams. Participants stated that seeing their body on the display created a feeling of uncomfortableness, which discouraged them from using video conferences for doctor appointments. Although they understood that it was necessary to see themselves as part of visual feedback to know what the doctor was looking at, they explained that showing any other part of their body other than their face was not what they normally did in a video call. The scenarios involved showing the throat, chest, and lower back. These body regions, as well as areas they would not expose in a normal social context, were considered 'private', and could make patients feel uncomfortable. Showing such body parts over video was deemed poor self-image management by patients.

> "I wasn't comfortable maybe because I don't see my mouth that way on everyday basis. So seeing an up-close camera and it was now focusing on my teeth, on my tongue and everything else. It wasn't necessarily what I do every day or even any day. So it was a very different angle of my own face or own stuff of which I wasn't very comfortable seeing that." –P1

Participants further interpreted that their self-image issues were solely in a human-human interaction context, as seeing themselves in a mirror would not create uncomfortable reactions because no other individuals were involved.

Moreover, video appointments were experienced to be different from their experience in the doctor's office. When they were examined in person, it was usually the doctor who focused on their body rather than patients themselves. While in the video visit, patients had to set up the device and focus more on their own body. Thus, not seeing their own body in the clinic might help avoid feeling self-conscious. This was reflected by comments from participants.

> "It's the fact that you're taping it yourself instead of the doctor. You're not actually in his office, you just sit there and he examines you, but you have to tape it yourself and figure out the angle and all of that. It makes it really, really uncomfortable." –P15

> "It would be definitely different from being there physically. If they have to do any kind of physical examination, they usually have a bed or a stretcher kind of thing. That's all it is set up in a specific part of the room and you go there, you follow some standard procedure and then the doctor is able to take, look at the body part and then you're done. But here you have to manually set all of that up. So it's more of the focus on my own body compared to what I would have there in the physical examination." –P5

Therefore, a participant considered it might be better to send pictures or videos rather than show their body live to reduce their exposure level.

> "If I'm facing any problem near the chest area…maybe an alternative that I could think of is taking a picture of my chest in advance instead of doing it on the call live. That might be easier for me compared to just doing that live on the call." –P5

Patients' Needs in Controlling Their Video Stream's Viewing and Sharing

The design features *hide my camera view* and *virtual cover* allow patients to control the timing of sharing their video stream and the amount of information they want to share. Participants found this truly helpful. *Hide my camera view* was treated as an initial process during which patients might need to take off their clothes and adjust the camera before making their body visible to the doctor. They felt it was inappropriate and awkward to remove their clothes in front of the doctor. Having such a feature would also allow them to still have the feedback from the camera. This was different from current video systems in that their own images would disappear when the camera was turned off.

> "In sort of a real-life scenario where the person would be taking off their top, right? It's nice to have that, so that you don't need to, for example, go to another room, and then take off whatever needs to be removed. They can just press this option and do that on the spot." –P18

> "In the real life, I would have to take off the shirt, so I would definitely use this while I'm getting ready." –P2

In addition, participants thought that the *virtual cover* feature could help them hide what was not necessary to be shown to the doctor. For example, in the *chest acne* scenario, participants felt that the doctor only needed to see the bumps on the skin, and it was unnecessary to have the whole chest area exposed. Some participants also believed that the privacy concern could be lower in such a scenario compared to going to the clinic.

> "I believe that the exposure level in the doctor's office is more. … I have had family members, one of our relatives, who had a colon surgery and they needed to go to the doctor to examine colon rectal cavities. They had issues with the doctor examining these areas. So I would imagine something like this would be more helpful for them." –P3

I also observed in the *chest acne* scenario where participants tended to place the camera on the table rather than holding it in their hand close to the chest. This was in contrast with showing the ankle in the *chronic pain* scenario, where they generally placed the camera very close to the foot. Still, this might also reflect that the virtual cover feature could reduce the workload of maneuvering the camera. Selection on the camera view might help the patient and doctor focus on the area needed to examine, as expressed by P1, "*from a perspective, if I only wanted to source certain region of the body and focus on that, that makes sense.*"

However, video systems not only need to provide such features but also need to better communicate how patients can control the viewing and sharing of their video streams. More specifically, systems need to communicate the status quo of their video stream (e.g., what is shared and what doctors can see). Participants expressed the feeling that the feedback was confusing when the hide camera view or virtual cover feature was turned on. First, they said they still saw the same image of themselves when using the *hide camera view* feature, though there was a prompt at the bottom saying that the doctor cannot see their image. This might create the illusion that the doctor can still see them. As P7 told us, "*I think I can hide my camera view, but because in my phone it still shows myself, so I feel a bit unsafe about that.*" Participants were clearly used to current video systems where other individuals can see them, when they are able to see themselves on the display. Thus, participants desired more obvious feedback, for example, a popup message on their images, or a change in the coloring of their camera view.

> "The color and the camera feed also doesn't change much. So if there was more of discernable change, let's say, my camera feed becomes grayed out, and there's some kind of overlay saying that's not recording anymore, not visible to the doctor anymore." –P5

Second, my current implementation of the virtual cover feature with a slider to change the transparency of the unselected area also resulted in ambiguous feedback to participants. They felt that changing the transparency feature was a way of blurring how much the doctor could see. For example, when the interface is darkened out with a specific visible area, P1 imagined the doctor would be able to see the exact video feed as what the patient was seeing.

> "What I think was happening was, the interface was telling me that as if this much area is darkened out and this is the visible one, and I was also imagining that the doctor is able to see that much area, but only slightly dark. So I wasn't sure if the doctor was not able to entirely see it. But if I were not to read that (prompt), I'd feel that the doctor is also seeing exactly what I am seeing. So the doctor is probably seeing a highlighted area on the bumps and the rest is like grayed out." –P1

Thus, participants wished to have fewer options for how they could see their blurred body, while they could still use the image as a reference for where to position the camera. As P6 told us, "*It was great on the plus side to be able to see the phone what's happening, I was able to glance at it and move the camera device*." Moreover, some participants also suggested that their camera stream should be darkened when the virtual cover button was pressed. Then the area they selected could be highlighted to indicate the area to be shown, which would be clearer than using only a red circle to pick the area. They also advised supporting free selection in case there might be multiple places they would need to show.

5.5. Discussion

In summary, my study confirmed the benefits of decoupling the camera and display and provided directions for potential improvements for such a multi-device video system. I identified current challenges in coordinating camera controls and in adjusting the video feedback, suggesting design features to support these needs. My findings also revealed patients' concerns behind distributing camera controls and sharing their video stream during a video consultation, highlighting the importance of trust in remote medical consultation. In this section, I discuss ideas for future design implications based on patients' use of the system.

5.5.1. Support Decoupling Camera and Display

My study revealed that decoupling the camera and display can provide more flexibility to help patients capture various body regions. Otherwise, they must rely on the doctor's verbal instructions to receive feedback. When using a single device such as a mobile phone, tablet, or desktop computer, it can be challenging for patients to see the display while capturing different parts of their body. Current video systems typically do not support such features, unless initiating a triadic video call, for example, using a laptop and a mobile phone to join the meeting. This typically brings further challenges in positioning two devices and coping with dual cameras and views. Prior research has explored configurations and usage of multiple devices in the workspace (Brudy *et al.*, 2019; Yuan *et al.*, 2022), where people might integrate several devices simultaneously to achieve a task. However, these supported tasks are quite different from my body exam tasks. In a workspace scenario, users usually work in a limited zone and devices are generally stationary without requiring highly mobile movements during the tasks. While in a body exam context the camera and display are highly mobile to allow patients to capture and view feedback simultaneously. Besides, interactions in general tasks are usually in front of users, while patients might interact with devices surrounding them. This is challenging because the examining work has been transferred from the doctor to the patient. Patients must play two roles: both an *examinee* and an *examiner*.

To deal with positioning and orienting challenges in using two devices, an intuitive idea is to reduce patients' work as an *examiner*. One approach could be decreasing patients' work of moving the camera or display. Previous research has explored camera control with panning and tilting functions, which can automatically follow a user's specific body part (Cheng *et al.*, 2013). The system may employ such features to capture patients' body gestures, such as walking, to avoid manually adjusting the camera or giving over camera control to the doctor. The display could also be flexible, for example, mounting it onto an arm that can support a high degree-of-freedom positioning in a space (Marquardt *et al.*, 2021). The assembly could provide patients with feedback on the camera view from a range of perspectives without the need to hold the display within their view. Another approach could be handing over camera control to the doctor. Telepresence robots have been used in conferences or homes (Neustaedter *et al.*, 2018; Yang and Neustaedter, 2018) and could potentially be used. This would resemble examinations in a clinic, yet the doctor would be embodied in the robot and examining patients in their homes. The most concerning issue is that patients are worried about showing too much of their home space and the robot could be out of the patient's control. The concern is also related to doctor-patient trust relationships. Thus, future research might explore how to manage the doctor's control and coordination work between them. In addition, I also see existing applications that use smartwatches as the display working with the phone camera to take photos or record videos. A similar method could involve using other wearable devices, for example, smart glasses (Mitrasinovic *et al.*, 2015). The issue is that such devices might not be accessible to patients in the home. Low-cost cardboard goggles working with the phone (Pan *et al.*, 2017) might help with the display positioning issue.

5.5.2. Support Distributive Camera Controls and Adjustable Video Feedback

Conducting video appointments in the home gives patients more autonomy and control over what the doctor can see. Patients are willing to grant minimum camera control to achieve the examination task. They hope the doctor can only see what is necessary to examine. This raises a design challenge. Patients must be aware of what kinds of exam the doctor will conduct, so they can set up the boundary of the camera view and consider that the camera may rotate. This may require the virtual appointment system to have pre-guidance before the appointment to inform patients what exams are involved. The set-up process should be efficient to avoid occupying too much time. To implement the control strategy, the video system should support features recognizing patients' bodies. Because the camera might be positioned differently, the system should be able to understand which area the camera is capturing. Prior work adopted a 360-degree camera for video conferencing, where the local user sees a portion of the remote environment (Tang *et al.*, 2017; Speicher *et al.*, 2018), which means the camera view is virtually controlled. This inspires a design that could allow patients to set up a virtual boundary that limits what viewing range the doctor can see.

Hiding the camera view and virtual cover feature allow patients to show what is necessary to examine. However, the interface design caused confusion in knowing what the doctor could see. Common video chat interface designs involve *seeing what other people see*. To comply with this principle, an extra viewport could be added on the patient’s side, showing the window of the doctor’s screen. Therefore, patients would know what the doctor is seeing to diminish confusion. Another solution could be providing clearer visual cues, for example, employing a translucent filter, adding a camera-off icon on the camera view, or using a pop-up prompt. Future work might explore what types of view feedback could be easier to perceive. The transparency changes of the unselected body area also create confusion over if the doctor can see it.

Considering that seeing one's private body could lead to discomfort, future designs should keep darkening the unshown camera view.

5.5.3. Support Patients' Trust Building During Video Consultation

Patient trust plays an important part in medical consultations, especially in remote settings. Prior literature often discusses patients' trust in technology systems (Jirotka *et al.*, 2005; Schüle *et al.*, 2022) as well as their trust in medical professionals (Bhat, Jain and Kumar, 2021; Seo *et al.*, 2021) in the healthcare context. The findings also highlight the critical role trust plays in video chat-facilitated consultation and suggest trust-building as an important consideration for future video-based systems.

When asking about concerns, participants expressed mostly privacy and security concerns with a video chat system. Prior work in studying patients' trust in technology systems discusses the importance of the permission and consent process in gaining trust, especially for systems that collect highly sensitive data (Luger and Rodden, 2013). Participants also discussed the needs for consent or legal agreement during a system's onboarding process to help address their concerns. The system's physical design can also help build patients' trust in the system by letting patients have physical means to protect their privacy. For example, adding a physical cover to the camera to help patients hide their camera feed, or having a removable battery source to completely turn it off. Thus, both interface and physical components should be considered when designing future video system features to support patients' trust building with the device.

My study found changes from offline to online settings (e.g., patients need to play roles both as an *examinee* and an *examiner,* with camera control responsibilities in remote exams) that could potentially affect doctor-patient relationship dynamics. Although most of the participants generally expressed their trust in doctors, they talked about potential scenarios and tasks they feel less comfortable with over video chat because they may not know the doctor well. The insights on distributing camera work responsibilities between doctors and patients demonstrate how patients' trust level affects how much control they feel comfortable giving doctors over the camera. Previous work often talks about supporting doctor-patient trust building during a more long-term process for promoting positive health outcomes for patients (Molassiotis, Morris and Trueman, 2007; Hall *et al.*, 2010; Holwerda *et al.*, 2013), while my study shows some insights on potential factors behind patients' trust during short-term video consultations. To support trust-building over video chat, future systems should consider design features that help doctors set a professional atmosphere and communication, to mimic the clinical setup that patients are used to. For example, having a built-in "start examination" feature for patients and doctors provides step-by-step instructions for doctors to walk through and lets patients adjust their camera feed (hide, cover, or show everything) at the beginning of each step. Future system design can also consider providing patients more transparency over what doctors can see and control during a video consultation to ensure doctors' access and control match patients' level of trust in them.

5.6. Summary

In this chapter, I described an exploratory study with eighteen participants where they attended mock video doctor appointments for five medical situations. These scenarios focused on camera work where participants manipulated the camera to show a range of body regions. Scenarios included: diarrhea, sore throat, chronic pain in the knee, chest acne, and post-surgery recovery. I observed how patient participants used the system during these mock scenarios and employed semi-structured interviews to learn about their reactions as well as their thoughts on different features to support capturing their body regions. Results show the benefits of providing more flexibility with a decoupled camera and display, and privacy protection by limiting the camera view. Yet, challenges remain in maneuvering two devices, presenting feedback of the camera view, coordinating camera work between the doctor and patient, and coping with discomfort in showing private body regions. This inspires future research on designing a video system for doctor appointments.

Chapter 6.

Conclusion

The thesis presents research on video conferencing for doctor appointments in home settings. The goal is to understand how people use video conferencing during doctor appointments and explore how to design systems to support the context. In this chapter, I summarize the contributions of this work. My research work was conducted through a series of three studies along with design work. They contribute to understanding patients' interactions in different types of medical situations. They also inform future designs of video conferencing systems to support patients seeing the doctor in their homes.

The overarching goal of this thesis is to address the following research problem:

How should we design video conferencing systems to support doctor appointments in home settings with patients?

It was investigated by addressing three sub-questions:

RQ 1: What are the needs of patients and doctors for video conferencing systems focused on home-based doctor appointments?

RQ 2: What design factors are important for designing video conferencing systems that can meet the needs of varying types of doctor appointments in the home setting?

RQ 3: How will patients use a video conferencing system that is specially designed for doctor appointments and what are the benefits and challenges when using the system?

Research contributions are presented respectively in this chapter.

6.1. Contributions

6.1.1. Understand the Needs

Research Question 1: What are the needs of patients and doctors for video conferencing systems focused on home-based doctor appointments?

I conducted an exploratory study with twenty-one patients and twelve family doctors. I designed six scenarios representing a range of medical situations covering different types of camera work and levels of privacy concerns. I used a scenario-based design method where participants were shown pre-recorded scenarios and interviewed about appointments utilizing a smartphone and general video conferencing software. Interview data was transcribed and coded to themes to describe patients' and doctors' reflections.

This study revealed challenges with camera work in examining patients via a smartphone camera. Video calls for doctor appointments are much different from a typical video call that one might have in other contexts, for example, for work or home life. Doctor appointments include more than conversations, such as showing various parts of one's body to a doctor, which is not always easy with a mobile phone. Mobile phones alone on the patient's side may not be ideal for video appointments when capturing patients at different scales, from their entire body that requires the camera to be placed at a distance away from patients, to be close enough to help the doctor see nuances of patients' different body areas.

This work informs designs of video systems for doctor appointments that should consider the types of camera work being used and what the camera is able to capture. Suppose a camera is placed far away in order to capture a patient's entire body. In that case, they may easily not be able to see the display to see the doctor or what is being captured by their camera, which would impede camera work. Doctors also sometimes need to see particular body parts that might be difficult for patients to reach to with a mobile phone camera. The camera work challenges suggest design opportunities for video appointment systems that allow doctors to observe patients in different ways. The design might consider involving more than one single device and the camera and display could be decoupled so that patients can still receive visual feedback on the display when the camera is posed differently. The study also shows that camera work for doctor appointments often requires intensive and effective collaboration between the doctor and patient. For example, doctors usually need to explicitly ask patients to show body parts or perform certain actions over video. This suggests designs should consider helping patients configure their camera and video conferencing setup to support doctors in seeing what they need to see.

The study also found that relationship-building played an essential role in doctor-patient appointments. Building relationships relies on conveying care in long-term encounters. Seeing different doctors over video could jeopardize trust relationships between doctors and patients. Challenges of conveying care also exist in terms of seeing body language on a small display, maintaining eye contact, and seeing body gestures, all of which are common issues with video calls in general when using a smartphone.

The study uncovers challenges related to privacy and video calls for doctor-patient appointments. Privacy is a highly studied area of research when it comes to video communication systems. We extend the field's understanding of this space by showing that video appointments for doctors and patients create unique situations with highly sensitive audio and video conversations. The challenges are similar to domestic and workplace video calls where bystanders may overhear or see things not intended for them (Boyle and Greenberg, 2005; Judge and Neustaedter, 2010; Judge, Neustaedter and Kurtz, 2010). In the case of video-based doctor appointments though, the privacy risks are potentially increased given the sensitive nature of some appointments, which means it is more critical to design systems in order to appease the privacy concerns of both doctors and patients. I investigated medical situations that could be privacy intrusive, such as exposing one's private body regions or talking about sensitive topics. The challenge was that patients were unlikely to drape themselves properly and, thereby, exposing parts of their bodies that are otherwise draped during in-person appointments. This may create issues around risking patients' dignity. This informs implications that future designs might compare the difference between face-to-face visits and virtual visits, and consider virtualizing ways of privacy protection that patients are given in a face-to-face appointment, for example, allowing patients to show the body area that is only necessary to be seen by the doctor during a video call. This suggests interface designs support more manipulations on patients' camera view to protect their privacy.

6.1.2. Prototype Design

Research Question 2: What design factors are important for designing video conferencing systems that can meet the needs of varying types of body examinations in the home setting?

I conducted a participatory design study that involved six patient partners in the design process. Three design sessions were conducted, including identifying research questions and goals, generating design ideas, and refining designs.

The participatory design study helped narrow the focus of my design work. It revealed several design areas to pursue and I narrowed in on one of them. First, my study revealed accessibility issues where patients faced challenges in waiting for service and booking appointments that were appropriate for video calls. These issues concentrate on coordinating work before the scheduled appointment time. The relationship building in terms of seeing the same doctor for continuity of care is focused on administration; thus, I did not pursue it as a focal area in my design work. Second, conveying care during doctor appointments, for example, making eye contact, or using comforting languages is out of the scope of the 'exam', which tends to address how to use the camera properly to see a patient's body. Thus, I did not focus on this area in my design work either. Third, the first study uncovered challenges around data security in that third parties might have access to doctor-patient conversations without awareness, which were worried by participants. This is not involved in my final design as well since it is a general challenge with video conferencing systems. Instead of these focal areas, I focused my design efforts on challenges that were centred on the 'camera' during video doctor appointments, including capturing different body parts, performing body actions, exposing private regions, and privacy concerns coming up. These aspects shaped the tasks I evaluated in the following study.

The study recognized design factors for the video conferencing system, which guided my further design proposals. Some of the design implications in my prior exploratory study were confirmed by patient partners that could be helpful in supporting varying types of doctor appointments. First, patient partners identified the need for seeing what the doctor sees during video calls. As such, the design work could explore the camera and monitor being separate. Second, to support capturing the patient's body at a larger scale or capturing their actions, the camera needs to be placed without being held in their hands. This suggests the design of the camera capable of being fixed and solitary. Third, to protect patients' dignity so they could behave appropriately in front of the camera when exposing private body areas, the video system could allow them to hide the camera view or solely show the area necessary for the assessment.

Based on these design factors, I proposed three design solutions and selected 'a handheld camera and a mobile phone' for the final design implementation. I learned from the design session that light-weighted mobility was highly valued by patient partners. They expected the video system to be easily deployed in their homes without concerns about the capacity of home space. This means a phone-sized system is more welcomed than a robot or a drone which may require more room to operate. The workshop also reflected patients' thoughts about autonomy in controlling their devices. They were concerned about the doctor invading their home space by controlling the camera to move and rove around. This also resonates with the finding in the evaluation study of the prototype (described more next).

Four design factors were proposed to guide further prototyping, including *Decouple camera and display*, *Free capturing*, *Hiding my camera view*, and *Virtual cover*. Then, I conducted an iterative design process, including brainstorming, hand sketching, creating low-fidelity prototypes, and generating the final 3D model, the prototype, Dr.'s Eye, containing an external camera and a novel user interface to support patients video calling their doctor. Patients can tilt the camera to get the desired camera orientation. The external camera and its case can be placed on a table surface or stuck onto vertical surfaces in a home environment, such as a wall. The design works with a mobile phone to connect to the doctor. The software user interface includes two main features: hide camera view, and virtual cover. Patients can turn off their video stream to the doctor, or partially select an area visible to the doctor which follows the body region when the camera moves.

The Dr.'s Eye is designed to help understand how patients use the four features in video calls with the doctor for varying medical situations, and further investigate what benefits and challenges emerge in the use of the video conferencing prototype.

6.1.3. Evaluation

Research Question 3: How will patients use a video conferencing system that is specially designed to support body examinations during doctor appointments and what are the benefits and challenges when using the system?

I conducted a study with eighteen patient participants where they attended mock video doctor appointments for five medical situations. These scenarios focused on camera work where participants manipulated the camera to show a range of body regions. Data collection came from semi-structured interviews and observations. Open, axial, and selective coding were processed to analyze the data.

The study revealed that decoupling the camera and display can provide more flexibility to help patients capture various body regions. A separated display allows patients to view the camera's feedback when the camera is posed away from them or out of patients' eyesight. The decoupling feature also brings up challenges in operating two devices simultaneously in a capturing task, which could increase patients' burden of usage. Further, I observed that patient participants preferred to operate one device while placing the other solitary. This was reported by participants as a more natural way to use. These challenges are caused by the transferring of examining work from the doctor to the patient. As such, patients play two roles, both as examiner and examinee. This suggests design work to reduce their workload, such as empowering automation on the camera to capture patients' body areas with fewer effort. Another concern came from the positioning of the display that it was not always easy to arrive at a comfortable view. The phone and camera were not well integrated that participants tended to treat them independently rather than as a whole. This informs the design to consider involving graphic elements that could inspire patients to assemble the camera and display together when the decoupling is not required during the video call.

This work uncovered communication issues between the patient and doctor due to their knowledge gap. Patients are not fully aware of what the doctor needs to see in a video call and how precisely they need to present their body images. Video conferencing changes the distribution of examining work such that these responsibilities are more distributed between doctors and patients during video appointments, in comparison with in-person visits where doctors have the majority of responsibilities. However, conducting video appointments in the home gives patients more autonomy and control over what the doctor can see. The study found that patients are willing to grant a minimal level of camera control to achieve the examination task. They hope the doctor can only see what is necessary to examine. This raises a design challenge in minimizing the knowledge gap. Design work may be required to consider how to guide patients on what exams are involved and how to conduct the camera work. This is also reflected in the design implications of the first study.

This study informs further designs of asymmetric camera views for doctor appointments. Hiding the camera view and virtual cover feature could protect patients' privacy. They allow patients to show what is necessary to examine. The prototype interface caused confusion in knowing what the doctor could see. It differs from typical video conferencing interface designs that people see what others can see. As a result, more explicit signs should be given on patients' video call interface so that they can be aware of what exactly the doctor is seeing when they apply different camera view features.

The findings highlighted the critical role of trust playing in video appointments with the doctor. The sensitivity level of patients' situations, the distribution of camera control, and pre-established relationships can all affect the trust dynamics during the video appointment. The study suggests design implications that might enhance trust relationship building using video conferencing, for example, providing an onboarding process to improve patients' awareness of granting access, adopting physical means in the design to help protect privacy, mimicking the clinical setup that patients are used to during the video call to help create a professional atmosphere.

To summarize, I list critical design implications that span across all of my three studies and present what findings are validated from the studies in Table 6.1.

Table 6.1 Design Considerations for Video Doctor Appointment Systems

Design Considerations	Study 1: Doctor & Patient Study	Study 2: Design Study	Study 3: Dr.'s Eye Evaluation
1. Decouple the camera and display. Designs can support the camera and display being decoupled when patients capture their bodies or actions.			
1a. Support patients constantly receiving visual feedback from the display.	√	√	√
1b. Support patients with the camera setup.	√		
1c. Support patients controlling the camera pose in a distance or automatically tracking patients' body areas.			√
2. Camera control distribution. Designs can allow the camera to be controlled for more efficient examining work.			
2a. Support being controlled by the remote doctor with authorization.	√	√	√
2b. Support limiting what the doctor is able to see, such as certain body regions or the home environment.		√	√
3. Camera view asymmetry. Designs can allow patients to selectively present their camera view to the remote doctor based on privacy preference.			
3a. Allow hiding the entire camera view from the doctor.		√	√
3b. Allow solely showing the body area needed for assessment.	√	√	√
3c. Present patients with lucid visual signs of what the doctor sees from their camera view.			√
4. Relationship building. Designs can support patients building trust relationships with the doctor.			
4a. Support a long-term process for continuity of care.	√		√
4b. Support eye contact and body language interaction.	√	√	
4c. Support an onboarding process and create a professional atmosphere to mimic clinics.			√

6.2. Future Work

This thesis introduced one video conferencing prototype for doctor appointments that focused on a subset of features in order to scope the research. There are many attempts that can be made as a part of future work. In this section, I list thoughts about designing for video doctor appointments in the home setting.

First, future work might consider conducting studies of actual doctor appointments. My prior study is based on mock doctor appointments in a lab setting. This means that portions of our data involve speculations about the nature of video appointments. The actual home configurations might be dissimilar to the lab setting, which could change the use of the system. Although I utilized a scenario-based method to let participants act as patients, people might also behave in other ways during actual appointments. Thus, different challenges might arise in field studies. Yet, challenges remain in that it could be difficult to find these varying types of doctor appointments, and both doctors and patients should consent to the data collection. A possible approach might be looking for patients with chronic health issues who need to visit their doctor regularly, or connect with specialist clinics.

Second, multi-device cooperation could be further investigated in future work. This thesis explored using an external camera and a mobile phone to conduct doctor appointments, revealing operating issues using two devices simultaneously. Multi-device cooperation could involve many types of combinations, for example, wearable devices such as smart watch or glasses, and other commonly accessible devices such as a tablet, laptop, or TV. They present different levels of mobility, and scales of visibility. It is interesting to understand the usability of adopting various combinations of such devices for doctor appointments in the home.

Third, doctor-patient coordination has not been deeply explored in my thesis. My study found that patients were willing to give over some camera control to the doctor when it was uneasy for patients to show their bodies. Meanwhile, they were uncomfortable handing over too much control, for example, allowing the doctor to look around their home space without limitations. It is still unclear what kinds of control can be granted to the doctor and how patients and doctors feel about the control re-distribution. Future work might create different types of camera control behaviors, such as panning, tilting, or moving; then conduct the study to understand how patients and doctors may make use of these control capabilities.

Fourth, a few elements could affect patients' concerns regarding privacy, for example, patients' feelings about identity and dignity, their trust in the doctor, and the creation of a professional atmosphere. My thesis employed hiding camera view and virtual cover features to help protect patients' dignity. This work implies that dissociating patients' identities might help reduce their uncomfortableness relating to sensitive topics. Processes like providing their awareness of types of exams, use of cameras, or controlling access might help enhance patients' trust in the doctor. In addition, creating virtual appointments procedures similar to in-person visits might help patients adopt examinations over video. These aspects have not been studied in this work but might reveal a deeper understanding of patient privacy in a video-facilitated doctor appointment context.

Fifth, future work might consider involving broader populations. Although my work covers a wide age group, people with accessibility issues or unfamiliar with technology were not involved in my study. They might be confronted with different challenges. These groups of people have higher needs for video doctor appointments. Creating technologies for accessibility is an additional design space that needs extra work to understand their specific needs. Technologies for general people may not apply to them. This means the hardware configuration and user interface might differ greatly from my current designs.

Lastly, future work might evaluate doctors' use of the Dr.'s Eye prototype. This thesis only evaluated the design work by patients. Still, it did not investigate how doctors would feel about the features created to support patients showing their bodies and what features are expected by doctors. Future work might consider adopting a similar approach as the participatory design study with patient partners, involving doctors to participate in the iterative design process based on the current Dr.'s Eye prototype. Then, the iterated system can be evaluated by doctor participants in varying medical scenarios.

6.3. Final Words

This dissertation has explored video conferencing systems for doctor appointments in home settings. A few topics emerged in this particular context, such as the use of the camera to capture body regions or actions, coordination between doctors and patients, doctor-patient relationships, as well as social concerns coming with the video calls for varying medical situations. This thesis presents a list of design implications that could support virtual doctor appointments, such as involving multi-device cooperation, arranging camera control distributions between doctors and patients, or assisting with building doctor-patient relationships. Designing for the home setting should think about the accessibility of devices. They must fit in the home space and can be easily adopted by end-users. Although this work is limited in not incorporating actual doctor appointments, it provides an approach to investigate such medical-related topics with great ethical concerns. Overall, this thesis explores a promising field where video doctor appointments have become more prevalent in this era.

References

Aggarwal, D. *et al.* (2016) 'Doctor, can you see my squats? Understanding bodily communication in video consultations for physiotherapy', in *DIS 2016 - Proceedings of the 2016 ACM Conference on Designing Interactive Systems: Fuse*. New York, New York, USA: ACM Press, pp. 1197–1208. doi: 10.1145/2901790.2901871.

Aggarwal, D. *et al.* (2017) 'SoPhy: A wearable technology for lower limb assessment in video consultations of physiotherapy', in *Conference on Human Factors in Computing Systems - Proceedings*. Association for Computing Machinery, pp. 3916–3928. doi: 10.1145/3025453.3025489.

Ames, M. G. *et al.* (2010) 'Making love in the network closet: The benefits and work of family videochat', in *Proceedings of the ACM Conference on Computer Supported Cooperative Work, CSCW*, pp. 145–154. doi: 10.1145/1718918.1718946.

Andersen, T. *et al.* (2014) 'Alignment of concerns: A design rationale for patient participation in eHealth', in *Proceedings of the Annual Hawaii International Conference on System Sciences*. IEEE Computer Society, pp. 2587–2596. doi: 10.1109/HICSS.2014.327.

Ansary, A. M., Martinez, J. N. and Scott, J. D. (2021) 'The virtual physical exam in the 21st century', *Journal of Telemedicine and Telecare*, 27(6), pp. 382–392. doi: 10.1177/1357633X19878330.

Arent, K. *et al.* (2017) 'Selected topics in design and application of a robot for remote medical examination with use of ultrasonography and auscultation from the perspective of the remedi project', *Journal of Automation, Mobile Robotics and Intelligent Systems*, 11(2), pp. 82–94. doi: 10.14313/JAMRIS_2-2017/20.

Armfield, N. R., Bradford, M. and Bradford, N. K. (2015) 'The clinical use of Skype-For which patients, with which problems and in which settings? A snapshot review of the literature', *International Journal of Medical Informatics*, pp. 737–742. doi: 10.1016/j.ijmedinf.2015.06.006.

Baishya, U. and Neustaedter, C. (2017) 'In Your Eyes: Anytime, Anywhere Video and Audio Streaming for Couples', in *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing - CSCW '17*, pp. 84–97. doi: 10.1145/2998181.2998200.

Bashshur, R. L. *et al.* (2016) 'The Empirical Foundations of Telemedicine Interventions in Primary Care', *Telemedicine and e-Health*, 22(5), pp. 342–375. doi: 10.1089/tmj.2016.0045.

Bellotti, V. and Sellen, A. (1993) ‘Design for Privacy in Ubiquitous Computing Environments’, in *Proceedings of the Third European Conference on Computer-Supported Cooperative Work 13–17 September 1993, Milan, Italy ECSCW ’93*, pp. 77–92. doi: 10.1007/978-94-011-2094-4_6.

Berry, A. B. L. *et al.* (2017) ‘“It’s good to know you’re not a stranger every time”: Communication about values between patients with multiple chronic conditions and healthcare providers’, *Proceedings of the ACM on Human-Computer Interaction*. Association for Computing Machinery, 1(CSCW), pp. 1–20. doi: 10.1145/3134658.

Bhat, K. S., Jain, M. and Kumar, N. (2021) ‘Infrastructuring Telehealth in (In)Formal Patient-Doctor Contexts’, *Proceedings of the ACM on Human-Computer Interaction*. ACM PUB27 New York, NY, USA, 5(CSCW2), p. 28. doi: 10.1145/3476064.

Boyle, M. and Greenberg, S. (2005) ‘The language of privacy: Learning from video media space analysis and design’, *ACM Transactions on Computer-Human Interaction*. ACM, pp. 328–370. doi: 10.1145/1067860.1067868.

Boyle, M., Neustaedter, C. and Greenberg, S. (2009) ‘Privacy Factors in Video-Based Media Spaces’, in *Media Space: 20+ Years of Mediated Life*. Springer, London, pp. 97–122. doi: 10.1007/978-1-84882-483-6_7.

Brubaker, J. R., Venolia, G. and Tang, J. C. (2012) ‘Focusing on shared experiences: Moving beyond the camera in video communication’, in *Proceedings of the Designing Interactive Systems Conference, DIS ’12*. New York, New York, USA: ACM Press, pp. 96–105. doi: 10.1145/2317956.2317973.

Brudy, F. *et al.* (2019) ‘Cross-device taxonomy: Survey, opportunities and challenges of interactions spanning across multiple devices’, in *Conference on Human Factors in Computing Systems - Proceedings*. Association for Computing Machinery, p. 28. doi: 10.1145/3290605.3300792.

Canon, S. *et al.* (2014) ‘A pilot study of telemedicine for post-operative urological care in children’, *Journal of Telemedicine and Telecare*. SAGE PublicationsSage UK: London, England, 20(8), pp. 427–430. doi: 10.1177/1357633X14555610.

Carroll, J. (2000) *Making use: scenario-based design of human-computer interactions*. MIT press.

Carroll, J. M. (1999) ‘Five reasons for scenario-based design’, in *Proceedings of the Hawaii International Conference on System Sciences*. IEEE Comp Soc, p. 123. doi: 10.1109/hicss.1999.772890.

Carter, M. *et al.* (2018) ‘Feasibility, acceptability and effectiveness of an online alternative to face-to-face consultation in general practice: A mixed-methods study of webGP in six Devon practices’, *BMJ Open*, 8(2), p. e018688. doi: 10.1136/bmjopen-2017-018688.

Casavant, D. W. *et al.* (2014) 'Trial of telemedicine for patients on home ventilator support: feasibility, confidence in clinical management and use in medical decision-making', *Journal of Telemedicine and Telecare*. SAGE Publications Ltd, 20(8), pp. 441–449. doi: 10.1177/1357633X14555620.

Castanho, T. C., Sousa, N. and Santos, N. C. (2017) 'When New Technology is an Answer for Old Problems: The Use of Videoconferencing in Cognitive Aging Assessment', *Journal of Alzheimer's Disease Reports*. IOS Press, 1(1), pp. 15–21. doi: 10.3233/adr-170007.

Chandwani, R. and De, R. (2013) 'Doctor-patient interaction in telemedicine', *Proceedings of the Sixth International Conference on Information and Communications Technologies and Development Notes - ICTD '13 - volume 2*, pp. 17–20. doi: 10.1145/2517899.2517934.

Chen, Y. *et al.* (2011) 'Unpacking exam-room computing: Negotiating computer-use in patient-physician interactions', *Conference on Human Factors in Computing Systems - Proceedings*, pp. 3343–3352. doi: 10.1145/1978942.1979438.

Cheng, D. *et al.* (2013) 'Body-Tracking Camera Control for Demonstration Videos', in *Conference on Human Factors in Computing Systems - Proceedings*. Association for Computing Machinery, pp. 1185–1190. doi: 10.1145/2468356.2468568.

Chudner, I. *et al.* (2019) 'Video or In-Clinic Consultation? Selection of Attributes as Preparation for a Discrete Choice Experiment Among Key Stakeholders', *Patient*. Springer International Publishing, 12(1), pp. 69–82. doi: 10.1007/s40271-018-0318-4.

De Cola, M. C. *et al.* (2016) 'Tele-health services for the elderly: A novel southern Italy family needs-oriented model', *Journal of Telemedicine and Telecare*, 22(6), pp. 356–362. doi: 10.1177/1357633X15604290.

Crampton, N. H., Reis, S. and Shachak, A. (2016) 'Computers in the clinical encounter: A scoping review and thematic analysis', *Journal of the American Medical Informatics Association*, pp. 654–665. doi: 10.1093/jamia/ocv178.

Creswell, J. W. and Poth, C. N. (2016) *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*. SAGE Publications.

Dillman, K., Tang, R. and Tang, A. (2016) 'Towards At-Home Physiotherapy : Next Generation Teleconferencing and Surface Based Interventions', in Maurer, F. (ed.) *SURFNET / Designing Digital Surface Applications*. NSERC Surfnet, University of Calgary, pp. 289–304. Available at: http://dspace.ucalgary.ca/handle/1880/50450.

Ding, X. *et al.* (2019) 'Boundary negotiation for patient-provider communication via Wechat in China', *Proceedings of the ACM on Human-Computer Interaction*. Association for Computing Machinery, 3(CSCW), pp. 1–24. doi: 10.1145/3359259.

Ding, X. *et al.* (2020) 'Getting the Healthcare We Want: The Use of Online "Ask the Doctor" Platforms in Practice', in *Conference on Human Factors in Computing Systems - Proceedings*, pp. 1–13. doi: 10.1145/3313831.3376699.

DiSalvo, C. and Gemperle, F. (2003) 'From Seduction to Fulfillment: The Use of Anthropomorphic Form in Design', in *Proceedings of the International Conference on Designing Pleasurable Products and Interfaces*. New York, New York, USA: ACM Press, pp. 67–72. doi: 10.1145/782896.

Dixon, R. F. and Stahl, J. E. (2008) 'Virtual Visits in a General Medicine Practice: A Pilot Study', *Telemedicine and e-Health*. Mary Ann Liebert, Inc. 140 Huguenot Street 3rd Floor New Rochelle, NY 10801 USA, 14(6), pp. 525–530. doi: 10.1089/tmj.2007.0101.

Domova, V., Vartiainen, E. and Englund, M. (2014) 'Designing a remote video collaboration system for industrial settings', in *ITS 2014 - Proceedings of the 2014 ACM International Conference on Interactive Tabletops and Surfaces*. New York, New York, USA: ACM Press, pp. 229–238. doi: 10.1145/2669485.2669517.

Erickson, T. (1995) 'Notes on Design Practice: Stories and Prototypes as Catalysts for Communication', in *Scenario-Based Design: Envisioning Work and Technology in System Development*. John Wiley & Sons, Inc., pp. 37–58. doi: 10.5555/209227.209231.

Eschler, J. *et al.* (2015) 'Designing Asynchronous Communication Tools for Optimization of Patient-Clinician Coordination.', *AMIA Annu Symp Proc*. American Medical Informatics Association, 11(5), pp. 543–552. Available at: http://www.ncbi.nlm.nih.gov/pubmed/26958188 (Accessed: 18 February 2020).

Farahani, B. *et al.* (2018) 'Towards fog-driven IoT eHealth: Promises and challenges of IoT in medicine and healthcare', *Future Generation Computer Systems*. North-Holland, 78, pp. 659–676. doi: 10.1016/j.future.2017.04.036.

Faucett, H. A., Lee, M. L. and Carter, S. (2017) '"I should listen more": Real-time sensing and feedback of non-verbal communication in video telehealth', *Proceedings of the ACM on Human-Computer Interaction*. Association for Computing Machinery, 1(CSCW), pp. 1–19. doi: 10.1145/3134679.

Gauglitz, S. *et al.* (2014) 'World-stabilized annotations and virtual scene navigation for remote collaboration', in *UIST 2014 - Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology*. New York, New York, USA: Association for Computing Machinery, Inc, pp. 449–460. doi: 10.1145/2642918.2647372.

Gordon, H. S. *et al.* (2020) '"I'm Not Feeling Like I'm Part of the Conversation" Patients' Perspectives on Communicating in Clinical Video Telehealth Visits', *Journal of General Internal Medicine*. Journal of General Internal Medicine, 35(6), pp. 1751–1758. doi: 10.1007/s11606-020-05673-w.

Graves, M. and Doucet, D. S. (2016) 'Factors Affecting Interprofessional Collaboration when Communicating through the use of Information and Communication Technologies: A Literature Review', *Journal of Research in Interprofessional Practice and Education*. CISP Journal Services, 6(2). doi: 10.22230/jripe.2017v6n2a234.

Grayson, D. M. and Monk, A. F. (2003) 'Are you looking at me? Eye contact and desktop video conferencing', *ACM Transactions on Computer-Human Interaction*. ACM, 10(3), pp. 221–243. doi: 10.1145/937549.937552.

Hall, A. M. *et al.* (2010) 'The influence of the therapist-patient relationship on treatment outcome in physical rehabilitation: A systematic review', *Physical Therapy*. Oxford Academic, 90(8), pp. 1099–1110. doi: 10.2522/ptj.20090245.

Hammersley, V. *et al.* (2019) 'Comparing the content and quality of video, telephone, and face-to-face consultations: A non-randomised, quasi-experimental, exploratory study in UK primary care', *British Journal of General Practice*. Royal College of General Practitioners, 69(686), pp. E595–E604. doi: 10.3399/bjgp19X704573.

Hansen, O. B. *et al.* (2021) 'Adaptation of the Foot and Ankle Physical Exam for Telehealth', *HSS Journal®: The Musculoskeletal Journal of Hospital for Special Surgery*. SAGE PublicationsSage CA: Los Angeles, CA, 17(1), pp. 85–90. doi: 10.1177/1556331620974675.

Harrison, S. (2009) 'A Brief History of Media Space Research and Mediated Life', in. Springer, London, pp. 9–16. doi: 10.1007/978-1-84882-483-6_2.

Hartzler, A. L. *et al.* (2014) 'Real-time feedback on nonverbal clinical communication', *Methods of Information in Medicine*. Schattauer GmbH, 53(5), pp. 389–405. doi: 10.3414/ME13-02-0033.

Heath, C. and Nicholls, K. (1986) *Body Movement and Speech in Medical Interaction*, *Body Movement and Speech in Medical Interaction*. Cambridge University Press. doi: 10.1017/cbo9780511628221.

Henderson, A. (2009) 'Constructing Space', in *Media Space 20+ Years of Mediated Life*, pp. 205–215. doi: 10.1007/978-1-84882-483-6_12.

Holwerda, N. *et al.* (2013) 'Do patients trust their physician? the role of attachment style in the patient-physician relationship within one year after a cancer diagnosis', *Acta Oncologica*. Taylor & Francis, 52(1), pp. 110–117. doi: 10.3109/0284186X.2012.689856.

Hsu, C. F. *et al.* (2019) 'Look at Me! Correcting eye gaze in live video communication', *ACM Transactions on Multimedia Computing, Communications and Applications*, 15(2), pp. 1–21. doi: 10.1145/3311784.

Hulsbosch, A. M. *et al.* (2017) 'Videoconferencing in a mental health service in The Netherlands: A randomized controlled trial on patient satisfaction and clinical outcomes for outpatients with severe mental illness', *Journal of Telemedicine and Telecare*, 23(5), pp. 513–520. doi: 10.1177/1357633X16650096.

Al Hussona, M. *et al.* (2020) 'The Virtual Neurologic Exam: Instructional Videos and Guidance for the COVID-19 Era', *Canadian Journal of Neurological Sciences / Journal Canadien des Sciences Neurologiques*. Cambridge University Press, 47(5), pp. 598–603. doi: 10.1017/cjn.2020.96.

Hutchinson, H. *et al.* (2003) 'Technology probes: Inspiring design for and with families', in *Conference on Human Factors in Computing Systems - Proceedings*. New York, New York, USA: ACM Press, pp. 17–24. doi: 10.1145/642611.

Islam, M. N. *et al.* (2018) 'SAFeBanD: A wearable device for the safety of women in Bangladesh', *ACM International Conference Proceeding Series*, (May 2019), pp. 76–83. doi: 10.1145/3282353.3282363.

Jang-Jaccard, J. *et al.* (2016) 'WebRTC-based video conferencing service for telehealth', *Computing*. Springer Vienna, 98(1–2), pp. 169–193. doi: 10.1007/s00607-014-0429-2.

Jirotka, M. *et al.* (2005) 'Collaboration and trust in healthcare innovation: The eDiaMoND case study', *Computer Supported Cooperative Work: CSCW: An International Journal*. Springer, 14(4), pp. 369–398. doi: 10.1007/s10606-005-9001-0.

Jiwa, M. and Meng, X. (2013) 'Video Consultation Use by Australian General Practitioners: Video Vignette Study', *Journal of Medical Internet Research*, 15(6), p. e117. doi: 10.2196/jmir.2638.

Johansson, A. M., Lindberg, I. and Söderberg, S. (2014) 'The views of health-care personnel about video consultation prior to implementation in primary health care in rural areas', *Primary health care research & development*, 15(2), pp. 170–179. doi: 10.1017/S1463423613000030.

Jones, B. *et al.* (2015) 'Mechanics of Camera Work in Mobile Video Collaboration', in *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. New York, NY, USA: ACM, pp. 957–966. doi: 10.1145/2702123.2702345.

Judge, T. K. *et al.* (2011) 'Family Portals: Connecting families through a multifamily media space', in *Conference on Human Factors in Computing Systems - Proceedings*. New York, New York, USA: ACM Press, pp. 1205–1214. doi: 10.1145/1978942.1979122.

Judge, T. K. and Neustaedter, C. (2010) ‘Sharing conversation and sharing life: Video conferencing in the home’, in *Conference on Human Factors in Computing Systems - Proceedings*. New York, New York, USA, New York, USA: ACM Press, pp. 655–658. doi: 10.1145/1753326.1753422.

Judge, T. K., Neustaedter, C. and Kurtz, A. F. (2010) ‘The family window: The design and evaluation of a domestic media space’, in *Conference on Human Factors in Computing Systems - Proceedings*. New York, New York, USA: ACM Press, pp. 2361–2370. doi: 10.1145/1753326.1753682.

Kirk, D. S., Sellen, A. and Cao, X. (2010) ‘Home video communication: Mediating “closeness”’, in *Proceedings of the ACM Conference on Computer Supported Cooperative Work, CSCW*. New York, New York, USA: ACM Press, pp. 135–144. doi: 10.1145/1718918.1718945.

Kvedar, J., Coye, M. J. and Everett, W. (2014) ‘Connected health: A review of technologies and strategies to improve patient care with telemedicine and telehealth’, *Health Affairs*. Health Affairs, 33(2), pp. 194–199. doi: 10.1377/hlthaff.2013.0992.

Landow, S. M. *et al.* (2014) ‘Teledermatology: Key factors associated with reducing face-to-face dermatology visits’, *Journal of the American Academy of Dermatology*. Mosby, 71(3), pp. 570–576. doi: 10.1016/j.jaad.2014.02.021.

Lee, J. J. and English, J. C. (2018) ‘Teledermatology: A Review and Update’, *American Journal of Clinical Dermatology*. Springer International Publishing, 19(2), pp. 253–260. doi: 10.1007/s40257-017-0317-6.

LeRouge, C., Garfield, M. J. and Hevner, A. R. (2002) ‘Quality attributes in telemedicine video conferencing’, *Proceedings of the Annual Hawaii International Conference on System Sciences*, 2002-Janua, pp. 2050–2059. doi: 10.1109/HICSS.2002.994132.

Li, H. L. *et al.* (2020) ‘Pilot Study Using Telemedicine Video Consultation for Vascular Patients’ Care During the COVID-19 Period’, *Annals of Vascular Surgery*. Elsevier, 68, pp. 76–82. doi: 10.1016/j.avsg.2020.06.023.

Li, K. F. (2013) ‘Smart home technology for telemedicine and emergency management’, *Journal of Ambient Intelligence and Humanized Computing*. Springer Berlin Heidelberg, 4(5), pp. 535–546. doi: 10.1007/s12652-012-0129-8.

Lim, C. *et al.* (2016) ‘“It just seems outside my health”: How patients with chronic conditions perceive communication boundaries with providers’, in *DIS 2016 - Proceedings of the 2016 ACM Conference on Designing Interactive Systems: Fuse*. New York, New York, USA: Association for Computing Machinery, Inc, pp. 1172–1184. doi: 10.1145/2901790.2901866.

Lindberg, B. *et al.* (2013) 'Using information and communication technology in home care for communication between patients, family members, and healthcare professionals: A systematic review', *International Journal of Telemedicine and Applications*. Hindawi Publishing Corporation, p. 31. doi: 10.1155/2013/461829.

Luger, E. and Rodden, T. (2013) 'An informed view on consent for ubicomp', in *UbiComp 2013 - Proceedings of the 2013 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, pp. 529–538. doi: 10.1145/2493432.2493446.

MacCormick, J. (2013) 'Video chat with multiple cameras', in *Proceedings of the ACM Conference on Computer Supported Cooperative Work, CSCW*. New York, New York, USA: ACM Press, pp. 195–198. doi: 10.1145/2441955.2442004.

MacKenzie, I. S. (2013) *Human-computer Interaction*. Elsevier. doi: 10.1016/C2012-0-02819-0.

Mairittha, T., Okita, T. and Inoue, S. (2018) 'Pre-consulting dialogue systems for telemedicine: Yes/no intent classification', in *UbiComp/ISWC 2018 - Adjunct Proceedings of the 2018 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2018 ACM International Symposium on Wearable Computers*. New York, New York, USA: Association for Computing Machinery, Inc, pp. 742–745. doi: 10.1145/3267305.3267704.

Marquardt, N. *et al.* (2021) 'AirConstellations: In-Air Device Formations for Cross-Device Interaction via Multiple Spatially-Aware Armatures', in *UIST 2021 - Proceedings of the 34th Annual ACM Symposium on User Interface Software and Technology*. Association for Computing Machinery, Inc, pp. 1252–1268. doi: 10.1145/3472749.3474820.

Mehrotra, A. *et al.* (2016) 'Utilization of telemedicine among rural medicare beneficiaries', *JAMA - Journal of the American Medical Association*. American Medical Association, 315(18), pp. 2015–2016. doi: 10.1001/jama.2016.2186.

Miller, E. A. (2001) 'Telemedicine and doctor-patient communication: An analytical survey of the literature', *Journal of Telemedicine and Telecare*, 7(1), pp. 1–17. doi: 10.1258/1357633011936075.

Miller, E. A. (2003) 'The technical and interpersonal aspects of telemedicine: Effects on doctor-patient communication', *Journal of Telemedicine and Telecare*. SAGE PublicationsSage UK: London, England, pp. 1–7. doi: 10.1258/135763303321159611.

Miller, M. K. *et al.* (2017) 'Through the looking glass: Effects of feedback on self-awareness and conversation during video chat', in *Conference on Human Factors in Computing Systems - Proceedings*. New York, NY, USA: Association for Computing Machinery, pp. 5271–5283. doi: 10.1145/3025453.3025548.

Mitrasinovic, S. *et al.* (2015) 'Clinical and surgical applications of smart glasses', *Technology and Health Care*. IOS Press Nieuwe Hemweg 6B, 1013 BG Amsterdam, The Netherlands, pp. 381–401. doi: 10.3233/THC-150910.

Molassiotis, A., Morris, K. and Trueman, I. (2007) 'The importance of the patient–clinician relationship in adherence to antiretroviral medication', *International Journal of Nursing Practice*. John Wiley & Sons, Ltd, 13(6), pp. 370–376. doi: 10.1111/J.1440-172X.2007.00652.X.

Neustaedter, C. *et al.* (2015) 'Sharing Domestic Life through Long-Term Video Connections', *ACM Transactions on Computer-Human Interaction*, 22(1), pp. 1–29. doi: 10.1145/2696869.

Neustaedter, C. *et al.* (2018) 'From being there to watching: Shared and dedicated telepresence robot usage at academic conferences', *ACM Transactions on Computer-Human Interaction*. Association for Computing Machinery, 25(6), pp. 1–39. doi: 10.1145/3243213.

Neustaedter, C. *et al.* (2020) 'Mobile Video Conferencing for Sharing Outdoor Leisure Activities Over Distance', *Human–Computer Interaction*, 35(2), pp. 103–142. doi: 10.1080/07370024.2017.1314186.

Neustaedter, C., Elliot, K. and Greenberg, S. (2006) 'Interpersonal awareness in the domestic realm', in *ACM International Conference Proceeding Series*. New York, New York, USA: ACM Press, pp. 15–22. doi: 10.1145/1228175.1228182.

Nguyen, D. T. and Canny, J. (2009) 'More than face-to-face: Empathy effects of video framing', in *Conference on Human Factors in Computing Systems - Proceedings*. New York, New York, USA: ACM Press, pp. 423–432. doi: 10.1145/1518701.1518770.

Ni, T., Karlson, A. K. and Wigdor, D. (2011) 'AnatOnMe: Facilitating doctor-patient communication using a projection-based handheld device', in *Conference on Human Factors in Computing Systems - Proceedings*. New York, New York, USA: ACM Press, pp. 3333–3342. doi: 10.1145/1978942.1979437.

O'Hara, K., Black, A. and Lipson, M. (2006) 'Everyday practices with mobile video telephony', in *Conference on Human Factors in Computing Systems - Proceedings*, pp. 871–880. doi: 10.1145/1124772.1124900.

Odom, W. *et al.* (2012) 'A fieldwork of the future with user enactments', in *Proceedings of the Designing Interactive Systems Conference, DIS '12*. New York, New York, USA: ACM Press, pp. 338–347. doi: 10.1145/2317956.2318008.

Ong, L. M. L. *et al.* (1995) 'Doctor-patient communication: A review of the literature', *Social Science and Medicine*. Pergamon, 40(7), pp. 903–918. doi: 10.1016/0277-9536(94)00155-M.

Orts-Escolano, S. *et al.* (2016) 'Holoportation', in *Proceedings of the 29th Annual Symposium on User Interface Software and Technology*. New York, NY, USA: ACM, pp. 741–754. doi: 10.1145/2984511.2984517.

Palen, L. and Dourish, P. (2003) 'Unpacking "privacy" for a networked world', in *Conference on Human Factors in Computing Systems - Proceedings*. New York, New York, USA: ACM Press, pp. 129–136. doi: 10.1145/642633.642635.

Pan, R. *et al.* (2017) '"Myeyes": The design and evaluation of first person view video streaming for long-distance Couples', in *DIS 2017 - Proceedings of the 2017 ACM Conference on Designing Interactive Systems*. New York, NY, USA: ACM, pp. 135–146. doi: 10.1145/3064663.3064671.

Pawlikowska, T. *et al.* (2007) 'Consultation models', in Charlton, R. (ed.) *Learning to Consult*. Oxford: Radcliffe Pub, pp. 192–229. doi: 10.1201/9781315378770-19.

Pejsa, T. *et al.* (2016) 'Room2Room: Enabling Life-Size telepresence in a projected augmented reality environment', in *Proceedings of the ACM Conference on Computer Supported Cooperative Work, CSCW*. New York, New York, USA: Association for Computing Machinery, pp. 1716–1725. doi: 10.1145/2818048.2819965.

Perera, G. *et al.* (2011) 'Views on health information sharing and privacy from primary care practices using electronic medical records', *International Journal of Medical Informatics*. Elsevier, 80(2), pp. 94–101. doi: 10.1016/j.ijmedinf.2010.11.005.

Powell, R. E. *et al.* (2017) 'Patient perceptions of telehealth primary care video visits', *Annals of Family Medicine*. American Academy of Family Physicians, 15(3), pp. 225–229. doi: 10.1370/afm.2095.

Rae, I. *et al.* (2015) 'A framework for understanding and designing telepresence', in *CSCW 2015 - Proceedings of the 2015 ACM International Conference on Computer-Supported Cooperative Work and Social Computing*. New York, New York, USA: Association for Computing Machinery, Inc, pp. 1552–1566. doi: 10.1145/2675133.2675141.

Rajabiyazdi, F. *et al.* (2017) 'Differences that matter: In-clinic communication challenges', in *ACM International Conference Proceeding Series*. New York, New York, USA: Association for Computing Machinery, pp. 251–260. doi: 10.1145/3154862.3154885.

Rho, M. J., Choi, I. young and Lee, J. (2014) 'Predictive factors of telemedicine service acceptance and behavioral intention of physicians', *International Journal of Medical Informatics*. Elsevier, 83(8), pp. 559–571. doi: 10.1016/J.IJMEDINF.2014.05.005.

Robinson, C. *et al.* (2016) ‘Using telemedicine in the care of newborn infants after discharge from a neonatal intensive care unit reduced the need of hospital visits’, *Acta Paediatrica, International Journal of Paediatrics*. Wiley/Blackwell (10.1111), 105(8), pp. 902–909. doi: 10.1111/apa.13407.

Rodeschini, G. (2011) ‘Gerotechnology: A new kind of care for aging? An analysis of the relationship between older people and technology’, *Nursing & Health Sciences*. John Wiley & Sons, Ltd, 13(4), pp. 521–528. doi: 10.1111/j.1442-2018.2011.00634.x.

Roter, D. L. *et al.* (2006) ‘The expression of emotion through nonverbal behavior in medical visits: Mechanisms and outcomes’, *Journal of General Internal Medicine*, 21(SUPPL. 1), pp. 28–34. doi: 10.1111/j.1525-1497.2006.00306.x.

Sanders, E. B. N., Brandt, E. and Binder, T. (2010) ‘A framework for organizing the tools and techniques of participatory design’, in *Proceedings of the 11th Biennial Participatory Design Conference on - PDC ’10*. New York, New York, USA: ACM Press, p. 195. doi: 10.1145/1900441.1900476.

Schüle, M. *et al.* (2022) ‘Patients’ Trust in Hospital Transport Robots: Evaluation of the Role of User Dispositions, Anxiety, and Robot Characteristics’, in *HRI ’22: Proceedings of the 2022 ACM/IEEE International Conference on Human-Robot Interaction*, pp. 246–255. doi: 10.5555/3523760.

Seo, W. *et al.* (2021) ‘Learning from healthcare providers’ strategies: Designing technology to support efective child patient-provider communication’, in *Conference on Human Factors in Computing Systems - Proceedings*. Association for Computing Machinery. doi: 10.1145/3411764.3445120.

Seuren, L. M. *et al.* (2020) ‘Physical Examinations via Video for Patients With Heart Failure: Qualitative Study Using Conversation Analysis’, *Journal of medical Internet research*. JMIR Publications Inc., 22(2), p. e16694. doi: 10.2196/16694.

Sevean, P. *et al.* (2009) ‘Patients and families experiences with video telehealth in rural/remote communities in northern Canada’, *Journal of Clinical Nursing*. Wiley/Blackwell (10.1111), 18(18), pp. 2573–2579. doi: 10.1111/j.1365-2702.2008.02427.x.

Shaw, S. *et al.* (2018) ‘Advantages and limitations of virtual online consultations in a NHS acute trust: the VOCAL mixed-methods study’, *Health Services and Delivery Research*, 6(21), pp. 1–136. doi: 10.3310/hsdr06210.

Shore, J. H. (2013) ‘Telepsychiatry: Videoconferencing in the Delivery of Psychiatric Care’, *American Journal of Psychiatry*. American Psychiatric AssociationArlington, VA, 170(3), pp. 256–262. doi: 10.1176/appi.ajp.2012.12081064.

Sodhi, R., Benko, H. and Wilson, A. D. (2012) 'LightGuide: Projected visualizations for hand movement guidance', in *Conference on Human Factors in Computing Systems - Proceedings*. New York, New York, USA: ACM Press, pp. 179–188. doi: 10.1145/2207676.2207702.

Speicher, M. *et al.* (2018) '360Anywhere: Mobile ad-hoc collaboration in any environment using 360 video and augmented reality', *Proceedings of the ACM on Human-Computer Interaction*. Association for Computing Machinery (ACM), 2(EICS), pp. 1–20. doi: 10.1145/3229091.

Spinuzzi, C. (2005) 'The methodology of participatory design', *Technical Communication*. Society for Technical Communication, 52(2), pp. 163–174. Available at: https://www.ingentaconnect.com/content/stc/tc/2005/00000052/00000002/art00005 (Accessed: 26 August 2020).

Steel, K., Cox, D. and Garry, H. (2011) 'Therapeutic videoconferencing interventions for the treatment of long-term conditions', *Journal of Telemedicine and Telecare*. SAGE PublicationsSage UK: London, England, 17(3), pp. 109–117. doi: 10.1258/jtt.2010.100318.

Street, R. L., Wheeler, E. J. and McCaughan, W. T. (2000) 'Specialist-primary care provider-patient communication in telemedical consultations', *Telemedicine Journal*. Mary Ann Liebert, Inc., 6(1), pp. 45–54. doi: 10.1089/107830200311842.

Stults, R., Harrison, S. and Harper, R. (2009) *Media Space 20 + Years of Mediated Life*, *Computer Supported Cooperative Work Series: Media space 20+ years of mediated life*. doi: 10.1007/978-1-84882-483-6.

Sun, S. *et al.* (2013) 'Messaging to your doctors: Understanding patient-provider communication via a portal system', in *Conference on Human Factors in Computing Systems - Proceedings*. New York, New York, USA: ACM Press, pp. 1739–1748. doi: 10.1145/2470654.2466230.

Swarup, S. and Makaryus, A. N. (2018) 'Digital stethoscope: Technology update', *Medical Devices: Evidence and Research*. Dove Medical Press Ltd, pp. 29–36. doi: 10.2147/MDER.S135882.

Tang, A. *et al.* (2017) 'Collaboration with 360° Videochat', in *Proceedings of the 2017 Conference on Designing Interactive Systems*. New York, NY, USA: ACM, pp. 1327–1339. doi: 10.1145/3064663.3064707.

Tang, R. *et al.* (2015) 'Physio@Home: Exploring visual guidance and feedback techniques for physiotherapy exercises', in *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems - CHI '15*. New York, NY, USA: ACM (CHI '15), pp. 4123–4132. doi: 10.1145/2702123.2702401.

Tates, K. *et al.* (2017) ‘The Effect of Screen-to-Screen Versus Face-to-Face consultation on doctor-patient communication: An experimental study with simulated patients’, *Journal of Medical Internet Research*. Journal of Medical Internet Research, 19(12), p. e421. doi: 10.2196/jmir.8033.

Taylor, A. *et al.* (2015) ‘Home Telehealth Video Conferencing: Perceptions and Performance’, *JMIR mHealth and uHealth*. JMIR Publications Inc., 3(3), p. e90. doi: 10.2196/mhealth.4666.

Unver, B. *et al.* (2018) ‘Hands-Free Remote Collaboration over Video: Exploring Viewer and Streamer Reactions’, in *ISS 2018 - Proceedings of the 2018 ACM International Conference on Interactive Surfaces and Spaces*. New York, New York, USA: Association for Computing Machinery, Inc, pp. 85–95. doi: 10.1145/3279778.3279803.

Uscher-Pines, L. *et al.* (2020) ‘Suddenly Becoming a “Virtual Doctor”: Experiences of Psychiatrists Transitioning to Telemedicine During the COVID-19 Pandemic’, *Psychiatric Services*. American Psychiatric AssociationWashington, DC, 71(11), pp. 1143–1150. doi: 10.1176/appi.ps.202000250.

VSee (2020) *Telemedicine Kits, Carts + Digital Medical Devices + Software*. Available at: https://vsee.com/hardware/ (Accessed: 3 June 2020).

Wang, M. W. (2017) ‘The study of teaching the smartphone using in taiwan’s elderly population—a case study in learners of the senior citizens academy in a city of Taiwan’, in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. Springer, Cham, pp. 477–485. doi: 10.1007/978-3-319-58530-7_36.

Weinstein, R. S., Krupinski, E. A. and Doarn, C. R. (2018) ‘Clinical Examination Component of Telemedicine, Telehealth, mHealth, and Connected Health Medical Practices’, *Medical Clinics of North America*. W.B. Saunders, pp. 533–544. doi: 10.1016/j.mcna.2018.01.002.

Wirtz, V., Cribb, A. and Barber, N. (2006) ‘Patient-doctor decision-making about treatment within the consultation - A critical analysis of models’, *Social Science and Medicine*, 62(1), pp. 116–124. doi: 10.1016/j.socscimed.2005.05.017.

Yang, L. and Neustaedter, C. (2018) ‘Our house: Living in a long distance relationship through a telepresence robot’, *Proceedings of the ACM on Human-Computer Interaction*. Association for Computing Machinery, 2(CSCW), pp. 1–18. doi: 10.1145/3274459.

Yuan, Y. *et al.* (2022) ‘Understanding Multi-Device Usage Patterns: Physical Device Configurations and Fragmented Workflows’, in *Conference on Human Factors in Computing Systems - Proceedings*. New York, NY, USA: ACM, p. 22. doi: 10.1145/3491102.3517702.

Appendix A.

Doctor & Patient Study

Ethics Approval

SFU
OFFICE OF RESEARCH ETHICS
dore@sfu.ca
http://www.sfu.ca/ore

Director 778.782.6593
Associate Director 778.782.9631
Manager 778.782.3447

Minimal Risk Approval – Delegated

Study Number: 2018s0299
Study Title: Video-Based Doctor Consultations in the Home

Approval Date: 2018 July 18
Principal Investigator: Han, Dongqi
SFU Position: Graduate Student

Expiry Date: 2019 July 18
Supervisor: Neustaedter, Carman
Faculty/Department: School of Interactive Arts and Technology

SFU Collaborator: Heshmat Dehkordi, Yasamin
External Collaborator: n/a
Research Personnel: n/a
Project Leader: n/a

Funding Source: none
Funding Title: n/a

Document(s) Approved in this Letter:

- Study Details, version date 2018 July 12
- Consent Form, version date 2018 July 12
- Recruitment Poster, version date 2018 July 12
- Appendix A: Interview Questions for Patients, version date 2018 July 12
- Appendix B: Interview Questions for Doctors, version date 2018 July 12

The application for ethical review and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human participants.

The approval for this Study expires on the **Expiry Date. An annual renewal form must be completed every year prior to the Expiry Date. Failure to submit an annual renewal form will lead to your study being suspended and potentially terminated.** The Board reviews and may amend decisions or subsequent amendments made independently by the authorized delegated reviewer at its regular monthly meeting.

This letter is your official ethics approval documentation for this project. Please keep this document for reference purposes.

This study has been approved by an authorized delegated reviewer.

SFU
RESEARCH ETHICS
dore@sfu.ca
http://www.sfu.ca/ore

Director 778.782.6593
Associate Director 778.782.9631
Manager 778.782.3447

Amendment Approval - Delegated

Study Number: 2018s0299
Study Title: Video-Based Doctor Consultations in the Home

Amendment Approval Date: July 31, 2019
Principal Investigator: Han, Dongqi
SFU Position: Graduate Student

Expiry Date: July 16, 2020
Supervisor: Neustaedter, Carman
Faculty/Department: School of Interactive Arts and Technology

SFU Collaborator: Heshmat Dehkordi, Yasamin
External Collaborator: N/A
Research Personnel: N/A
Project Leader: N/A

Funding Source: N/A
Funding Title: N/A

Document(s) Approved in this Amendment:

- Amendment Form uploaded on July 30, 2019
- Study Details uploaded on July 30, 2019
- Consent Form – Doctors uploaded on July 30, 2019
- Consent Form – Patients uploaded on July 30, 2019
- Flyer uploaded on July 30, 2019

The amendment(s) for ethical review and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human participants.

Please note that approval of the amendment(s) does not change the expiry date on the current SFU REB approval of this study. The approval for this study expires on the **Expiry Date. An annual renewal form must be completed every year prior to the Expiry Date. Failure to submit an annual renewal form will lead to your study being suspended and potentially terminated.**

This letter is your official Amendment Approval documentation for this project. Please keep this document for reference purposes.

<u>**The amendment to this study has been approved by an authorized delegated reviewer.**</u>

Interview Questions

Interview Questions for Patients

Background Questions:

1. Can you tell me your age, occupation, education level?
2. Can you tell me about your general health? You only need to describe what you are comfortable sharing.
3. How often do you visit doctors? Is it regular or only when you feel uncomfortable? If it is regular, what do you usually talk to your doctor about?
4. Can you tell me about a visit or visits that you think went really well? What happened? Why did it go well? You only have to share what you are comfortable with sharing. We can skip this question if you like, or you can talk generally about the situation.

□ What was bothering you?

□ How long was the appointment? How did you feel about this?

□ How long did you wait in the waiting room? How did you feel about this?

□ Were you by yourself or with others?

□ How did you describe your situation?

□ Did the doctor ask about your medical history? If yes, in what forms, is it necessary?

□ Did you get examinations? If yes, what kind of examinations?

□ Did you get a prescription from doctor?

□ What did the doctor recommend you do next?

□ Do you need further visits or this time a follow-up visit?

□ If yes, what examinations will you need to take?

5. Can you tell me about a visit or visits that you felt frustrated with or embarrassed with? What happened? Why did it not go well? Again, you only have to share what you are comfortable with sharing. We can skip this question if you like, or you can talk generally about the situation.
6. Do you think it's always necessary to visit doctors in person? Do you think it can be done with text messaging, audio or video chatting? In what conditions and in what conditions not?
7. What factors do you think are important during the consultations?
8. Do you trust your doctor? What factors affect your trust in them? (like professional skills, patience, attitudes, etc.) Do you expect more explanations or examinations from your doctor?

Scenarios followed by questions

<read to participant>

Next, I will present you with various scenarios and then ask you some questions based on them. For each scenario, I will read you a description of a patient in the scenario and you'll see a short video of the sample consultation. I will video record your reactions to the scenario. Each scenario will portray a kind of condition consulting with the doctor.

For the scenarios, we can have you view them for a patient named, Anna, or Ethan. Which would you prefer?

<depend on the response, use either "Anna" or "Ethan" and the associated pronouns in the following scenarios>

Scenario 1: Cold

Ethan had a cold for the last few days and his throat was becoming sore. He woke up with a fever of 101.2 F / 38.4 C. He called his doctor's office to schedule a video appointment for later that day. The appointment time came and the doctor video called Ethan. He answered the call on his phone in his home kitchen. He could see the doctor on the phone, just like the doctor could see him. The doctor asked what the problem was and Ethan explained his symptoms. The doctor asked Ethan to hold the phone up so the doctor could see in his mouth. The doctor asked Ethan to shift the camera up a little and to the left, and say, "Ahhhhh." Ethan followed the directions. The doctor told Ethan that his throat was red, but it was likely just a normal cold. There was nothing he could do. Ethan should rest and drink lots of liquids. Ethan thanked the doctor and the call ended.

Scenario 2: Fall while jogging

Ethan was jogging in the morning when he didn't notice there was a small hole on the path in front of him. He fell down on the road, which caused him to scrape his knee and hit his stomach on a rock. Ethan scheduled a video appointment with his doctor for later that day to see if it was a serious injury or not. He took the video call from his living room at home. During the appointment, Ethan explained what happened on his jog by talking into the camera on his phone where he could also see his doctor's face. Then, he switched to using the back camera and showed his knees to the doctor. The doctor asked Ethan to show him his belly. Ethan lifted up his shirt and uncovered his belly. He switched the phone back to using the front camera. He held his phone in one hand and followed the doctor's instructions to press on different parts of his belly and abdomen with the other hand at different positions. The doctor told Ethan that nothing seemed to be problematic. Ethan thanked his doctor and ended the video call.

Scenario 3: Sleeplessness

Ethan had been struggling with the work for a few weeks and felt very stressful out. At night time, Ethan falling asleep easily. Some nights he felt like he only had 2 or 3 hours of sleep. The sleeplessness condition lasted for days. Ethan setup an appointment to have a video call with his doctor for a time when he knew he would be at home alone. When the appointment came, he was seated at his kitchen table. He held his mobile phone in front of him and told the doctor about his sleeplessness condition.

He said this made him feel irritable at work and sometimes he felt quite depressed. The doctor asked him how much coffee he was drinking, if he was taking other drugs, or if he drank alcohol and how much. Ethan told him that he drank 3 cups of coffee a day and would routinely have several glasses of whiskey before bed. He thought this helped him sleep. The doctor was concerned and suggested that Ethan should see a counselor to discuss the challenges he was facing. Ethan thanked the doctor and the call ended. The doctor sent a referral to a counseling office who would follow up to make an appointment with Ethan.

Scenario 4: Embarrassing issues

Ethan noticed one day that he had a rash on his arm and it felt quite itchy. He was a little worried because he didn't know what it was from. He called his family doctor for consultation. The doctor asked him questions about what he ate and drank, where he went, or whether was exposed to strong sunlight. Nothing seemed unusual. Then, the doctor asked him if he had used any drugs recently. Ethan didn't expect the doctor would ask this although he thought it was irrelevant to his rash. He still answered the doctor honestly but felt awkward when saying that he had smoked marijuana a few days before. The doctor told Ethan that there was a possibility it contained an additional chemical that reacted with Ethan. He prescribed Ethan with a topical solution that he could apply to the rash. The prescription was electronically delivered to Ethan's pharmacy so he could pick it up later that day. Ethan thanked the doctor and the call ended.

Scenario 5: Domestic abuse

Ethan often faced friction with his wife and sometimes they would argue. One day after breakfast, they quarreled over who should wash the dishes and somehow, they started to fight. Ethan was pushed down to the ground by his wife, which bruised his arm and forehead. Later that day when his wife was not around, he called her doctor because he felt dizzy and nauseated. He didn't want his neighbors or other people to see his injury, and he didn't think he could make it to the hospital or clinic due to being dizzy. So he scheduled a video appointment with the doctor later in the afternoon to check his physical status. He took the call on the couch in the living room. During the appointment, he explained to the doctor how he fell down on the ground and showed the doctor his injured forehead and arm. The doctor was worried about his being dizzy and nauseated. Ethan was asked a few questions concerning cognitive competence. The doctor believed he was fine and told him to get more rest in bed for the next few days. If he didn't feel better, he needed to make an appointment again. Ethan thanked the doctor and the call ended.

Scenario 6: Private parts

<Note: this video will not show a person's genitals. This part of the video clip will be blocked/blurred.>

It is time for Ethan's annual exam. Ethan called his doctor for a video examination. They scheduled it for the following week. When the appointment time came, Ethan video called the doctor's office from his home bedroom. The doctor asked Ethan some basic questions about his health such as, "Have you experienced any health concerns?" Ethan said, no. The doctor then asked Ethan to remove his clothes except for his underwear and move the camera around his body so he could ensure there was nothing visually problematic. Ethan did as instructed and moved the phone camera around. Next, the doctor asked Ethan to show his private parts to him. Ethan took off his underwear and brought the phone camera towards his genitals. The doctor examined them visually. He then instructed Ethan that he could put his underwear back on. The doctor asked questions like how many sexual partners he had in recent months, whether he engaged in safe sexual practices and if his partners had any sexually transmitted diseases. The doctor concluded the exam and told Ethan he seemed healthy. Both hung up the video call.

Questions (asked after each scenario)

1. How do you feel about the consultation? Is this something you could see working over a video call? Why or why not?

2. How would the appointment differ if it was in person vs. over video like this?

3. Would your reaction to the scenario be different if this was a desktop computer, a large screen, or a 360-degree camera? Which one do you prefer? Why?

4. Would your reaction be different if a nurse was present? (or medical students/your kids/partner?)

5. Would your reaction be different if the doctor was a different gender?

6. Do you think video-mediated methods could fit the needs of the consultation? In what situations do you think they fit? If you have a choice, would you choose in-person consultation or video-based consultation for this kind of situation? Why?

7. What do you think are the benefits and challenges of video-based consultations?

8. Do you have any suggestions to improve the experience?

Interview Questions for Doctors

Background Questions:

1. Can you tell me your age?

2. What's your profession (general practitioner or specialist)? How many years of experience do you treat patients?

3. What days and what time do you work? How many patients do you see per week? How long does a patient take generally?

4. Do the patients need to make appointments before? How long does it usually take? Are there exceptions? In what situations don't they need to?

5. Can you tell me about the last time you saw a patient? (don't provide identifying information about your patients)

   □ What was his/her condition?

   □ Was his/her first visit? If not, how was the progress?

   □ Was it an emergent situation? How did he/she look like?

□ Did he/she make an appointment?

□ How did you make diagnosis? (What information did you need?)

□ Did he/she get examinations? What kind of examinations?

□ What treatment did he/she need? (drugs, physical therapy, etc.)

□ How long did the treatment need?

□ Did it need professional care or it can be done by him/herself?

□ Did he/she need further visits? If yes, what kind of examinations did he/she need?

6. Can you tell me a visit or visits that you think went really well? What happened? Why did it go well? You only have to share what you are comfortable with sharing. We can skip this question if you like, or you can talk generally about the situation.

7. Can you tell me a visit or visits that did not go well? What happened? Why did it not go well? Again, you only have to share what you are comfortable with sharing. We can skip this question if you like, or you can talk generally about the situation.

8. What do you expect from patients to make diagnoses? What do they usually miss when describing their conditions? Or what kind of information they cannot provide but necessary to make diagnoses?

9. As a doctor, what do you do to try and create a positive experience for patients?

What factors do you think are important within patient-doctor consultations? (like attitude, eye contact, trust, or pleasant conversation)

10. Would jokes help to defuse uncomfortable or embarrassed situations?

11. Do you think your patients trust you? Why? How do you try to make patients trust you, if at all?

12. Do you think it is necessary to visit in person every time? Why? In what situations it is and in what situations it isn't?

Questions (asked after each scenario)

9. How do you feel about the consultation? Is this something you could see working over a video call? Why or why not?

10. How would the appointment differ if it was in person vs. over video like this?

11. Would your reaction to the scenario be different if this was a desktop computer, a large screen, or a 360-degree camera? Which one do you prefer? Why?

12. Would your reaction be different if a nurse was present? (or medical students/the patient's kids/the patient's partner?)

13. Would your reaction be different if the patient was a different gender?

14. Do you think video-mediated methods could fit the needs of the consultation? In what situations do you think they fit? If you have a choice, would you choose in-person consultation or video-based consultation for this kind of situation? Why?

15. What do you think are the benefits and challenges of video-based consultations?

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

Recruitment Poster

SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

SCHOOL OF INTERACTIVE ARTS + TECHNOLOGY

Video-Based Doctor Consultations in the Home

We are conducting research to explore doctors' and patients' needs for home

WE ARE LOOKING FOR
FAMILY PHYSICIANS

Help us by participating in an interview study to explore video-based doctor appointments.

$150 for participation | 1 Hour Interview
Any Places and Time upon your preference

Please contact any of the researchers below if you are interested.

Dongqi Han: dongqih@sfu.ca　　**Dr. Carman Neustaedter: carman@sfu.ca**

Appendix B.

Evaluate Dr.'s Eye Study

Ethics Approval

SFU RESEARCH ETHICS

Minimal Risk Approval – Delegated

Study Number: 30000598
Study Title: Evaluating A Video System for Doctor Appointments in the Home

Approval Date: April 27, 2022 **Expiration Date:** April 27, 2023
Principal Investigator: Carman Neustaedter **SFU Position:** Faculty
Faculty/Department: School of Interactive Arts and Technology

Student Lead: Dongqi Han
SFU Collaborator(s): Chelsea Mills, Denise Geiskkovitch
Research Personnel: N/A
External Collaborator(s): N/A

Funder: NSERC Discovery Grant
Funding Title: The Design of Family Communication Technologies in Pandemic and Post-Pandemic Society
Funding Number: R611600

Document(s) Approved in this Application:

- TCPS 2 CORE Tutorial Certificate for Dongqi Han dated June 4, 2018
- TCPS 2 CORE Tutorial Certificate for Chelsea Mills dated January 19, 2021
- TCPS 2 CORE Tutorial Certificate for Denise Geiskkovitch dated September 9, 2012
- Consent Form, version dated April 25, 2022
- Recruitment Scripts, version dated April 26, 2022
- System Features Document, version dated April 25, 2022
- Interview Questions, version dated April 25, 2022
- Participant Scenarios, version submitted April 26, 2022
- Script for in-lab activities, version submitted April 26, 2022

The application for ethical review and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human participants.

The approval for this Study expires on the **Expiration Date. An Annual Renewal must be completed every year prior to the Expiration Date. Failure to submit an Annual Renewal will lead to your study being suspended and potentially terminated.** The Board reviews and may amend decisions or subsequent amendments made independently by the authorized delegated reviewer at its regular monthly meeting.

This letter is your official ethics approval documentation for this project. Please keep this document for reference purposes.

This study has been approved by an authorized delegated reviewer.

SIMON FRASER UNIVERSITY ENGAGING THE WORLD Page **1** of **1**

Interview Questions

This study includes two sections. In the first section, you will be asked about some of your doctor appointment experiences. And in the second section, you will be using our video system, which includes a mobile phone and this, to mock a few doctor appointments over video. I'll introduce the details later okay? Please feel free to ask if you have any questions or concerns during the study. I hope you can feel relaxed and comfortable.

Let's go with the first section.

Background Questions: (~3min)

1. Can you tell me your age, occupation?
2. Have you ever had video doctor appointments? Do you remember what were the reasons you need to see the doctor?
    a. What apps did you use?
3. (Without video visit experience) Is there any reason you did not try video appointments?

(Ask follow-up questions based on participants' response.)

Let's continue with the section 2.

First, I'm gonna introduce the device we will use. When we use our phone to video call someone, we use the front or rear camera to capture and the screen to see the remote person, right? And you can simply treat this device as the camera, it's just separate from the phone screen. We are not using the phone cameras, instead, we only use this camera. And the phone works as a display.

Introduction to device and user interface:

As you can see, at the top of it is a camera, you can twist the camera to adjust the view angle (show to participants when saying this). Also you can see the lids on the front and back side. If you flip them over, the reusable tape will show up, and you may stick to a solid flat surface, like the phone, wall, or tv or even table leg. But it cannot stick to soft or rough things like couch (show it and tell participants to use gently). When you start a video call, just click this button here (show it) you will open a webpage, and you can see, this is the doctor's view, and this is your camera's view. You may click the small view to switch which view you want it bigger. When you click "Hide my camera view", you can see yourself, but the doctor cannot see you when you turn it on. You can see there's a hint text at the bottom. When you turn it off, the doctor can see you again. You may turn it on if you feel you need to get prepared before letting the doctor see you. For the virtual cover feature, I'll show you later on.

Next, we will do role-playing. You play as a patient, and I play as a family doctor. We will go through five different scenarios. In each scenario, you will have different medical situations. We will have a video call. You are in your home, I'll be sitting behind the divider like I'm in the doctor's office. After each scenario, I'll come back and ask you a few questions. (Just let you know that I'm not the real doctor, but I'll do my best to make our doctor-patient conversation be realistic**.) (**So you know, this study is not to evaluate you. The purpose is to evaluate the user interface and design of these features. So I hope you may give us your opinions from the perspective of a patient, so we could know what would help and what should be improved. We want to know where the design does not meet your needs, so problems are greatly appreciated.**)** Do you have any questions?

So you know, we have view recording over there, screen recording on the laptop, and audio recording on this phone.

Interview for scenarios:

1) Diarrhea

Hello xxx, how may I help you? [diarrhea]. I'm so sorry to hear that. How long have you had the diarrhea? [a week]. How often you need to use the washroom per day? [3-5] I know it must be very tough for you to go through this. Was there anything you feel it might be related to? Like anything you ate, drank. [bbq] Okay, it could be. But let's do a lab test first to see what's in there, okay? I'll also give you some medication so you would feel better before we figure out what caused the problem, okay? Do you have any other concerns? [no] Okay, please do the test as quick as you can, take the meds and see if it helps. I'll see you later. Byebye.

Questions:

1. How do you feel about using it for this situation? Is this something you could see working over a video call? Why or why not?
    a. Did you have any concerns about your privacy? If so, please explain.
    b. Was it easy or difficult to show the camera view of yourself to the doctor? Why?

2. (Based on observation) I noticed you did…, could you explain it?

3. Do you think the system feature (x) can meet the needs for this kind of situation? Why or why not?

4. If not, how do you think the system can be improved? And why?

5. How do you compare (our system) to (commercial app)?

2) Sore throat

Hello xxx, how may I help you? [sore throat]. I'm sorry to hear that. How long has this been going? [3 days] Do you have a fever? [no] Can you show me your throat? Please open your mouth and say 'AHHH'.

I can see it's a bit swollen, but I didn't see pus. I'll prescribe a swab and blood test, and see if you have any bacterial infection, okay? You can come back and see me after the results come out, okay?

Questions:

1. How do you feel about using it for this situation? Is this something you could see working over a video call? Why or why not?
    a. Did you have any concerns about your privacy? If so, please explain.

b. Was it easy or difficult to show the camera view of yourself to the doctor? Why?

2. (Based on observation) I noticed you did…, could you explain it?

3. Do you think the system feature (x) can meet the needs for this kind of situation? Why or why not?

4. If not, how do you think the system can be improved? And why?

5. How do you compare (our system) to (commercial app)?

3) Chronic pain on your knee.

Hello xxx, I see that you have been on our new medication for two weeks. Have you been taking the pills every day? [yes] Great. I'm gonna ask you to do some lifting and stretching for me, okay? Can you please lift up your upper leg with both of your hands and slowly stretch your lower leg to the front? Do you feel any pain? (1-10) Can you show me your ankle and press on it and let me see if there's any fluid?

That's a positive sign that your pain level goes down a little bit, and I didn't see fluid retention in your ankle. Let's see how it goes for the next one month, okay? See you next time.

Questions:

1. How do you feel about using it for this situation? Is this something you could see working over a video call? Why or why not?

    a. Did you have any concerns about your privacy? If so, please explain.

    b. Was it easy or difficult to show the camera view of yourself to the doctor? Why?

2. (Based on observation) I noticed you did…, could you explain it?

3. Do you think the system feature (x) can meet the needs for this kind of situation? Why or why not?

4. If not, how do you think the system can be improved? And why?

5. How do you compare (our system) to (commercial app)?

4) Chest acne.

(You have some pimples on your chest area. In this case, I'm not asking you to take off your clothes and show the chest area. Instead, you can see, I have markers here. Can you please put them on your chest area? When you put the camera in front of the markers, it will recognize the markers and you can see on the phone that there is a chest image overlaying your chest area. You know we all have different body shapes, colors. It is not possible to find an image that has perfect matching. We will be using a neutral drawing. But I hope that when we run this scenario, you could try to imagine you really have your own chest exposed and show the area to the doctor. And I'd like to know your reactions to it.)

Hello xxx, how may I help you today? [bumps on chest] How long has this been? [1 week] Do you feel itching? [no] Can you show me?

It looks like acne to me. I'll prescribe some retinoids. Let's see if they would work. You may use the cream on the pimples three times a week at first, if there's no allergic reactions, use them daily. And we can see how effective after four weeks, okay?

Questions:

1. How do you feel about using it for this situation? Is this something you could see working over a video call? Why or why not?
    a. Did you have any concerns about your privacy? If so, please explain.
    b. Was it easy or difficult to show the camera view of yourself to the doctor? Why?

2. (Based on observation) I noticed you did…, could you explain it?

3. Do you think the system feature (x) can meet the needs for this kind of situation? Why or why not?

4. If not, how do you think the system can be improved? And why?

5. How do you compare (our system) to (commercial app)?

5) Post-surgery recovery

(You have a lumbar discectomy, it's a surgery on your lower back. This is a follow up, the doctor will check the healing status of the surgical wound. You are going to show the lower back area to the doctor.)

Hello xxx, hope you are doing well. This is a follow up for your lumbar surgery. Last time you had X-ray and full lab tests. All the results show pretty well. This time I'm gonna check the scar on your back and see how it has healed. Can you please lift up your shirt and lower down your pants so I can see the surgical area? Do you feel any pain?

I can see the cut is healing well, and there's no swelling. Please keep taking the medication and let me know if you have any uncomfortable feelings, okay?

Questions:

1. How do you feel about using it for this situation? Is this something you could see working over a video call? Why or why not?
    a. Did you have any concerns about your privacy? If so, please explain.
    b. Was it easy or difficult to show the camera view of yourself to the doctor? Why?

2. (Based on observation) I noticed you did…, could you explain it?

3. Do you think the system feature (x) can meet the needs for this kind of situation? Why or why not?

4. If not, how do you think the system can be improved? And why?

5. How do you compare (our system) to (commercial app)?

Questions after scenarios:

1. In general, what features you like and what features you don't like? How do you think the features (you don't like) could be improved?

2. The whole system design, not limited to the software and hardware. How do you think it can be improved if you use it in your home as a tool for doctor appointments? What features you would expect?

3. If you were using this in your home, what room would you choose to use it in? (Living room, bedroom, washroom, etc.) Why? How would you place it to capture you?

4. Do you think there would be other situations that would work well or not work well for using the system? Why? (e.g. mental health, drug/alcohol addiction)

5. How do you feel about seeing yourself in the doctor appointments?

[Study ends]

Recruitment Poster and Script

Email script for recruitment:

[to mailing lists, including snowballing and university mail lists.]

Hello,

We are conducting a study to evaluate a video conference system specialized for family doctor appointments. We explore how the creation of new features can meet the needs of video appointments for different types of medical situations. More details can be found in the attached consent form. If you are interested or want more details, please directly contact Dongqi at dongqih@sfu.ca. You will be reimbursed $30 or 1.5 course credits for participating in our study (1~1.5 hours). Please help forward to any other people you think who might be interested in this study. Thank you!

Social Media script:

We are conducting a study to evaluate a video conference system specialized for family doctor appointments. We explore how the creation of new features can meet the needs of video appointments for different types of medical situations. Look forward to your inputs! You will be reimbursed $30 or 1.5 course credits for participating in our study (1~1.5 hours). If you are interested or want more details, please directly contact Dongqi at dongqih@sfu.ca. (Please do not respond to this post publicly. As a friendly reminder, sharing or posting to the comments will expose your identity.)

Response email to people who see the ad on social media and contact us:

Hello,

Thanks for your interest in our study. Please see the attached document for the consent form. It introduces more details about our study and what you may be asked to do during the study. Don't hesitate to ask if you have any questions. If you want to participate, please let us know your available time. Thank you!

Poster