

Understanding Clinician Perspectives to Identify Opportunities for Telemedicine Beyond COVID-19

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Due to the COVID-19 pandemic and efforts to protect patients and staff, many in-person appointments were replaced with virtual visits via telemedicine tools. However, it is unknown how prepared the clinicians were to use these tools and how appropriate they were for daily practice. We explored this issue by surveying 105 clinicians about their experiences with telemedicine tools. Clinicians reported that their perceptions of telemedicine improved since COVID-19 started. We found there are logistical benefits of telemedicine (e.g. staying on schedule) and certain types of appointments and situations are better suited for telemedicine (e.g. follow-ups and mental health). Despite increased interest in using telemedicine long-term, clinicians shared that these platforms need to better support virtual physical exams and rapport building. To deal with these drawbacks, some clinicians developed creative workarounds, which should be considered when designing future telemedicine tools. We discuss opportunities for making telemedicine more appropriate for long-term use.

CCS CONCEPTS • Human-centered computing • Human computer interaction (HCI) • Empirical studies in HCI

Additional Keywords and Phrases: healthcare, clinicians, COVID-19, telemedicine, virtual visits

ACM Reference Format:

First Author's Name, Initials, and Last Name, Second Author's Name, Initials, and Last Name, and Third Author's Name, Initials, and Last Name. 2018. The Title of the Paper: ACM Conference Proceedings Manuscript Submission Template: This is the subtitle of the paper, this document both explains and embodies the submission format for authors using Word. In Woodstock '18: ACM Symposium on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY. ACM, New York, NY, USA, 10 pages. NOTE: This block will be automatically generated when manuscripts are processed after acceptance.

1 INTRODUCTION

The global COVID-19 pandemic and the policies in response to the pandemic have immensely impacted society, governments, and healthcare systems. In order to protect patients, clinicians, and staff, healthcare systems have begun implementing telemedicine tools to replace in-person appointments. Telemedicine refers to the use of technology to provide and support healthcare at a distance [17]. In this paper, we focus on real time communication between clinician and patient through voice or video calls, which was widely used during

the COVID-19 pandemic. However, are clinicians prepared to use these tools; and how usable are these tools for everyday work? This current study tackles this pressing question. HCI researchers have discussed the benefits of telemedicine for years [56] and the recent, rapid implementation has led to a broader interest in telemedicine tools. We used this renewed interest in telemedicine to understand how these tools can continue provide long-term benefits.

Through rapid integration of telemedicine tools into clinical workflows, healthcare professionals created the opportunity to explore telemedicine in everyday life and learn from current experiences. A NIH report suggests that telemedicine tools will be a typical part of our healthcare experience going forward [34], thus, we must quickly learn from different stakeholders' experience to improve telemedicine and prepare for the long-term use of these tools. Previous work has explored the patient perspective of telemedicine during the COVID-19 pandemic but less is known about the clinician perspective [59] even though understanding the clinical perspective is necessary for ensuring long-term uptake of these tools in standard care. This paper provides insight into clinicians' experiences with telemedicine tools following the quick uptake of these platforms in 2020. We report on situations appropriate and inappropriate for telemedicine from the clinicians' perspective, positive aspects of these tools from the clinicians' perspectives, challenges encountered, and opportunities to make these tools more appropriate for long-term use.

After 20 years of slow integration of audio and video-based telemedicine [33], healthcare institutions have rapidly ramped up their use of these tools since the pandemic. Historically, institutions have been slow to implement audio and video-based remote care into their daily practice [29,75]. As of 2018, only half the hospitals in the United States reported providing telemedicine and telehealth-based services [41]. However, the COVID-19 pandemic forced the widespread adoption of telemedicine in order to reduce the demand on the health care infrastructure and reduce the exposure for patients and providers [9,73]. The widespread adoption was also due to the US Department of Health and Human Services removing restrictions and waiving certain requirements of the Health Insurance Portability and Accountability Act (HIPAA), which allows for the use of telemedicine platforms not previously deemed compliant [32]. Several hospitals have reported over a 4000% increase in telemedicine visits since the start of the pandemic [53,68,79]. Additionally, the Centers for Medicare & Medicaid Services along with multiple commercial insurance providers have begun reimbursing telehealth visits at the same rate as in-person visits during the COVID-19 pandemic [32].

To understand ways to improve the design of telemedicine, we surveyed 105 clinicians about their use of telemedicine and opinions about it. We found that there are many logistical benefits to telemedicine. However, there were also many challenges to remote care, such as the inability to perform physical exams and the difficulty with consistent internet access. To combat these challenges, clinicians developed and employed various workarounds. However, even with these workarounds, it seems that certain types of visits and clinical activities are better suited for telemedicine than others. It is important to understand how to make telemedicine tools more useful and equitable. Our contributions to the CHI community include:

- We describe situations appropriate for telemedicine, benefits of telemedicine, and challenges to telemedicine as reported by clinicians three months after COVID-19 was declared a pandemic.
- We report on workarounds used by clinicians to support their ability to provide remote care.
- We identify opportunities for HCI and health informatics research to support remote care, increase access to care, and make telemedicine usable for long-term use.

2 RELATED WORK

2.1 Benefits of Audio-Video Telemedicine

Telemedicine has many socio-economic benefits [42], high patient satisfaction [68], and so far no clinical disadvantages have been found [32]. The socio-economic benefits of telemedicine include improved access to care, decreased cost, and increased quality of life [42]. One study on the economic benefits of telemedicine found that virtual care that replaced an emergency department visit saved, on average, between \$309 and \$1546 and virtual visits that replaced outpatient physician office visits saved between \$84 and \$131 [60]. Patients also believe that virtual visits save money; results from a survey found that 75% of patients indicated that virtual visits saved them money [44].

Telemedicine appointments have also been found to have high patient satisfaction [68], which is associated with treatment plan adherence [37] and is essential for value-based care [64]. A study on patient satisfaction with the telehealth program at CVS MinuteClinics from before the COVID-19 pandemic found that one third of about 1700 adult patients preferred a virtual visit to a traditional in-person appointment [63]. Video appointments, compared with in person office visits, have been found to be less stressful for patients [22]. A randomized controlled trial found that patients with urinary incontinence who received care from a virtual clinic, as opposed to a standard clinic, scored significantly higher on the Patient Experience Questionnaire (PEQ) in the domains of Communications, Emotions, and Barriers [43]. This is consistent with other studies that found patients report better communication with their provider [37] and strengthened patient-provider relationships [70] when using video-based telemedicine tools as opposed to traditional, in-person appointments. Additionally, several previous studies have reported that patients find virtual visits more convenient than in-person office visits [22,70]. One study at a VA Hospital in Vermont found that telemedicine saves the patient an average of 145 miles and 142 minutes per visit [74]. While there is a substantial amount of research about benefits of telemedicine from the patient's perspective, less is known about clinician-perceived benefits to telemedicine. To address this gap, we investigated benefits of telemedicine from the clinician's point of view.

2.2 Barriers to Implementing Audio-Video Telemedicine

While there are many benefits to telemedicine, there are also barriers that must be addressed. Among rural emergency departments in the United States without telemedicine, 37% reported cost concerns as the reason for nonuse. Implementing video-based telemedicine may require investment into the technologic infrastructure, communication networks, data storage and equipment systems, and data security [48]. The need for such investments might not provide cost benefits as reported by some studies [78].

There have been several systematic reviews that investigated factors that support or hinder telemedicine implementation. For example, a 2018 systematic review identified commonly reported barriers to telemedicine: organizational barriers (e.g. reimbursement, legal liability, confidentiality concerns), patient barriers (e.g. education, technology literacy), and staff barriers (e.g. resistance to change, licensing issues) [80]. Another systematic review explored determinants of a successful telemedicine implementation [12]. They found that the most common determinants identified by previous studies were related to HCI elements: technology support, training, and usability and clinician and patient acceptance. Other factors include organizational work practices, financial cost of implementation, and policy and legislation.

These previous studies highlight the importance of stakeholder support and acceptance in order for a successful implementation of telemedicine [12,80,83]. According to the Technology Acceptance Model (TAM) [19], actual use and intended use of information systems, like telemedicine, can be predicted by attitudes towards the systems [49]. A study applied TAM to clinicians' decisions to accept telemedicine tools found that the model was sufficient in explaining acceptance [38]. The same study found that perceived usefulness significantly predicted attitude towards telemedicine and intention to use the tool. The current study expands on this research and qualitatively explores clinician perceptions of telemedicine. We investigate workarounds used by clinicians to alleviate the barriers and challenges of telemedicine in order to find methods for increasing acceptance.

2.3 Clinicians' Perceptions of Audio-Video Telemedicine

Clinician perceptions of telemedicine have not been as widely studied as patient perceptions of telemedicine and even less is known about clinician perceptions after the emergence of the COVID-19 pandemic [59]. It is important to understand how the COVID-19 pandemic and the associated uptake in telemedicine use has impacted perceptions of telemedicine because perceptions will impact its future success [3,38,81].

Several studies have shown that clinicians have had generally positive perspectives of telemedicine after the quick uptake due to the pandemic [5,27,76]. A survey with urologists found that the majority liked using telemedicine and found it simple to use, easy to learn, and felt that they could be productive using it [25]. Another study found that there was a significant shift in the physicians' perceptions of telemedicine since using it during the pandemic and they were more open and willing to adopt telehealth services in the future [35].

However, other studies have reported lukewarm clinician perceptions [52]. One common concern is the perceived difficulty in building rapport and communicating with the patient [39]. Based on previous research, this concern is not unfounded. A systematic review of doctor-patient communication via telemedicine found that non-verbal behaviors are not adequately communicated virtually [57]. Other studies have also found that patients and clinicians have concerns about establishing rapport and the limited opportunities to see body language by video [15,65].

The discrepancy in whether clinicians are satisfied with telemedicine may be related to the purpose and nature of the appointment, where some types of appointments are more appropriate remotely than others. A survey of physicians in New York City during the pandemic found that providers thought telemedicine would be useful once the pandemic is over for follow up visits, medication refills, urgent care, dermatology visits, behavioral health, and chronic care management [59]. The same survey found that pediatricians were most willing to continue using telemedicine post COVID-19 and internal medicine providers were least willing. Another study found that dermatologists and orthopedics had the lowest levels of adoption while psychiatrists and endocrinologists had the highest levels of adoption [24]. The current study adds to this literature by reporting on additional situations in which telemedicine could be useful and situations unsuited for telemedicine. Moreover, we extend on existing literature by using clinical perspectives to think about how the design of telemedicine platforms can be enhanced to support long-term use.

2.4 HCI and Audio-Video Telemedicine

While extensive HCI and CSCW research has been conducted on various aspects of telemedicine, such as asynchronous communication [21], monitoring tools [8], and clinical decision support systems [91], research on

audio-video telemedicine for remote visits has not been as adequately studied. Previous HCI work on audio-video telemedicine has mainly focused on potential uses [72], descriptive studies about its use in rural communities [84], and patient perspectives [47]. Additionally, prototypes have been developed to integrate virtual reality (VR) and augmented reality (AR) technologies into virtual visits [1], however, the ubiquity of this technology is still a long way off.

Specific to video clinical visits, previous HCI and CSCW work has explored patient-provider relationships and communication via video. One study found that doctors felt a stronger rapport with patients via video when they had a previous in-person appointment with the patient [16]. Another study found that patients in a rural community found video consultations acceptable even though they strongly value their relationship with their doctor [67]. Systems have also been designed to enhance patient-provider communication during video clinical visits. For example, Faucett and colleagues [26] created a system to improve clinicians' nonverbal communication behaviors during virtual visits by using real-time sensing to monitor their nonverbal cues.

Our work adds to the existing HCI literature by exploring how audio-video telemedicine is used in daily clinical practice from the perspective of the clinician and implications on the future design of telemedicine. COVID-19 has shown that telemedicine is a necessary tool for increasing healthcare access and improving patient safety. Our study uses this momentum to consider how these tools, which are now being more widely implemented than ever before, can be better designed to promote long-term use.

3 METHODS

We conducted a survey about the use of telemedicine during the COVID-19 pandemic. This study was approved by the Institutional Review Board of [anonymized].

3.1 Recruitment

The survey's target population included clinicians (physicians, nurse practitioners, therapists) from all settings and all expertise. Participants were recruited through social media and mailing lists. We used snowball sampling [50], asking participants to share the survey with their colleagues. Participants were eligible if they were a practicing clinician and used telemedicine at least once in the past year.

3.2 Survey Design

The survey was developed by a team of researchers across a variety of fields, including HCI, computer science, and medicine. See Appendix 1 for the full survey. Participants were first asked to provide basic information about their work, such as their clinical role, medical specialty, and years of experience. Then participants were asked several multiple-choice questions such as frequency of telemedicine use, technologies used, and attitude towards using telemedicine. Finally, participants were asked several open-ended questions about aspects of care that are easier and harder to deliver well using telemedicine. Additionally, participants were asked what workarounds or special strategies they use to make appointments as good as possible. The survey took between 5 and 15 minutes to complete.

3.3 Data Collection and Analysis

Data collection occurred between June 7, 2020 and August 4, 2020, starting about three months after COVID-19 was declared a pandemic by the World Health Organization [93]. The survey was distributed through the

volunteer-based online platform LabintheWild [71]. Following [30,71], we motivated participation by offering an anonymous summary of responses at the end of the survey so that the participant can compare their own experiences with those of other clinicians. One person was removed due to ineligibility (they were not a practicing clinician) and eight were removed for not completing the survey (they started the survey but did not answer any of the questions used in analysis).

Open-ended survey questions were analyzed using an inductive approach. Themes and categories were identified by the first author after reviewing all the free-text responses. The themes were then discussed and iterated as a group. A coding framework was developed and then applied to all free-text survey responses using established techniques of coding [11].

4 RESULTS

We received 114 survey responses. 105 clinicians completed the full survey and 97 participants completed the multiple-choice questions but not the open-ended ones. See Table 1 for participant characteristics of the sample. The most common specialty was Pediatric Medicine and Subspecialties (n = 63), followed by Neurology (n = 16), and Adult Medicine and Subspecialties (n = 14). The average number of years of clinical care experience was 17.26, ranging from one year to 41 years (SD = 9.20). Prior to COVID-19, the majority of participants (76%, n = 80) had never used telemedicine tools for scheduled clinical appointments. Since COVID-19, 93% (n = 98) of participants use telemedicine tools (phone or video) to see patients.

Table 1: Characteristics of Participants

Characteristic	Number of Participants (%)
Used telemedicine prior to COVID-19	
Yes	25 (24%)
No	80 (76%)
Used telemedicine since the start of COVID-19	
Yes	103 (98%)
No	2 (2%)
Technologies used in place of in-person appointments	
Voice only calls	71 (68%)
Video calls from phone	54 (51%)
Video calls from tablet or computer	81 (77%)
Other	0 (0%)
No virtual clinical appointments conducted	2 (2%)
Clinical Role	
Doctor	98 (93%)
Nurse Practitioner	2 (2%)
Therapist	5 (5%)
Other	0 (0%)
Years of Experience	
1 to 5	11 (10%)
6 to 10	17 (16%)
11 to 15	21 (20%)
16 to 20	23 (22%)
21 to 25	13 (12%)
26 to 30	13 (12%)
31+	7 (7%)

Characteristic	Number of Participants (%)
Specialty	
Pediatric Medicine and Subspecialties	63 (60%)
Neurology	16 (15%)
Adult Medicine and Subspecialties	14 (13%)
Psychiatry	5 (5%)
Family Medicine	4 (4%)
Other	3 (3%)

Participants were asked to report their attitude towards telemedicine before the pandemic and currently (three to five months into the pandemic) on a 5-point Likert scale with 1 being very skeptical and 5 being very enthusiastic (see Figure 1). On average, before the pandemic, clinicians reported their attitude as 2.66 (SD = 1.36) and after the start of the pandemic, clinicians reported their attitude as 3.87 (SD = 1.09, Wilcoxon Signed Rank S=2340, $p < .0001$).

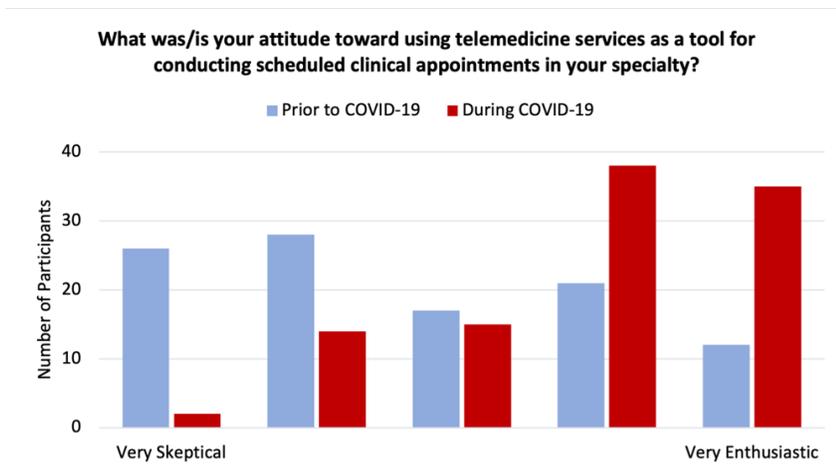


Figure 1: Attitude towards telemedicine prior to COVID-19 and during COVID-19.

Additionally, participants were asked about their attitude toward using telemedicine services in the future on a 5-point Likert scale with 1 being much less and 5 being much more (see Figure 2). On average, clinicians reported their attitude towards using telemedicine in the future as 4.02 (SD = 1.15).

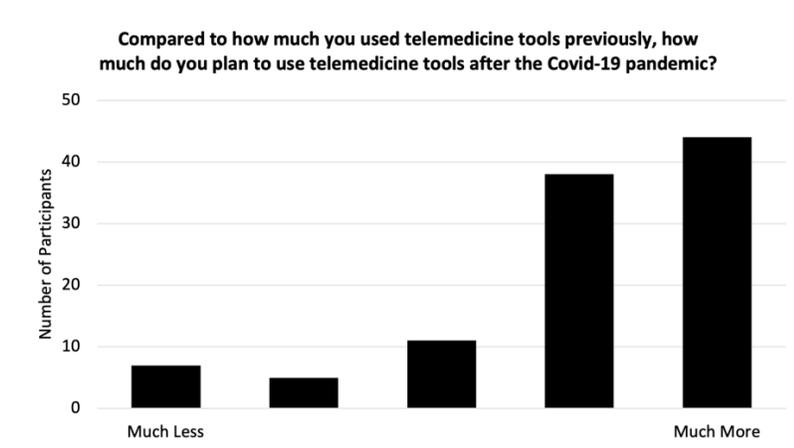


Figure 2: Attitude towards using telemedicine in the future.

Below, we detail clinician-perceived appropriate and inappropriate uses of telemedicine, clinician-perceived benefits of telemedicine, clinician-perceived challenges of telemedicine, and then strategies developed to mitigate the challenges of telemedicine.

4.1 Clinician-Perceived Appropriate and Inappropriate Uses of Telemedicine

Many participants used the open-ended fields to indicate which situations and populations they perceive to be appropriate for virtual visits and which situations they perceive to require in-person appointments. Participants reported that virtual visits are appropriate for routine follow ups, behavioral health, mental health, medication reconciliation and refills, triage, chronic pain, basic dermatology, history taking, answering questions, providing recommendations and connecting with resources, nutrition, sleep, consults, and reviewing results. Participants reported that the type of patient who would benefit most from virtual visits are younger people, people with children, kids at college, people who work, people with limited access to transportation, patients who are deaf, people who live far away, and people who have difficulty travelling.

Participants reported that virtual visits are inappropriate for new patients, infant well checks, exams (particularly physical, neurological, oral, cardiac, and genital exams), strength and reflex testing, reviewing behavioral and mental health homework, delivering bad news, rashes, ear pain, developmental delays, monitoring lymph nodes, and situations in which it is important to monitor emotional cues. Participants reported that the type of patient who would not benefit from virtual visits are patients without access to technology, older patients, infants, teenagers who do not have privacy, patients with complicated histories, and patients requiring a translator.

4.2 Clinician-Perceived Benefits of Telemedicine

Of the 97 participants who answered at least one open-ended question, 70% used the open-ended text boxes to report positive aspects to telemedicine, such as removing barriers to care, helping clinicians stay on schedule, and allowing clinicians to observe the patient's home environment.

Many participants reported that telemedicine is beneficial because it removes barriers to accessing care. Of the participants who responded to the open-ended questions, 6% stated that telemedicine is beneficial because

it **reduces the burden of transportation** on the patient. For example, one pediatrician said *"Mom did not have to drive 3 hrs just to hear me talk."* Telemedicine also improves access to care by allowing the clinician to see more patients throughout the day. One clinician reported that *"If technology runs smooth we have a higher capacity for volume of patients."* Additionally, as stated by 13% of participants, patients have been less likely to cancel their appointments, with one participant stating that since the introduction of telemedicine *"no shows have gone down significantly"*.

Telemedicine also appears to support system optimization by **allowing clinicians to stay on schedule** and have more time to talk with patients. Through the open-ended responses, 4% of participants noted that, since the start of telemedicine they feel as if they have done a better job with staying on schedule. One participant stated that they are staying on schedule because the participant *"Got to start the appointment as soon as I was ready rather than waiting for front desk staff to check the patient in and for the MAs to check vitals, which is the biggest source of appointment delay normally in clinic."*

An unintended benefit to telemedicine has been providing the clinicians a unique **opportunity to observe the patient's home environment** and their home context, noted by 10% of participants. This is useful to clinicians because they can *"see the patients living environment which is helpful in understanding factors that contribute to their conditions."* Additionally, the clinicians are able to view some aspects of safety of their patients through their home environment. A neurologist who specializes in Parkinson's disease reported that they *"like to take tours of my patients' home, especially the bathrooms, stairs-- it's like doing a home safety evaluation!"* Telemedicine affords a peek into the patient's daily life that is not accessible from traditional in-person appointments. A fuller understanding of the patient's home life is helpful for understanding the patient's general well-being and creating treatment plans specific to the patient.

4.3 Clinician-Perceived Challenges of Telemedicine

While there were several positive aspects of using telemedicine, 86% of clinicians also used the open-ended text box to report several challenges to using telemedicine, such as inability to perform an exam, difficulty building rapport and having personal conversations, connection and quality issues, and insufficient patient technical skills/technology literacy.

The majority of participants (82%) reported through the open-ended responses being unable to perform a proper exam. In fact, 25% of these participants indicated that they cancelled an appointment because of the **inability to perform a physical exam**. One pediatrician stated that it is *"absurd to think you can diagnose without touching a pediatric patient. You will miss many problems without a physical exam. This is basics [sic] of human diagnosis."* Similarly, a neurologist reported that *"tests that require in person assessment are more difficult. For example, some tests of motor recovery are validated in person but not via telehealth."*

While many conditions require a physical exam to diagnose, rashes were the most frequently reported condition that was difficult to diagnose without a traditional exam. For example, one participant reported that *"rashes are hard because they are harder to see and sometimes being able to feel them adds to the ability to make an accurate diagnosis."* The inability to perform a proper exam may have been due to the inflexibility of the patient's camera. For example, a psychiatrist reported difficulty performing a neurological exam because *"when a person sits back to show more of their body one can no longer see the face well as we can with our eyes across an exam room."* Another situation in which the physical exam is particularly tricky is when it is a

genital exam. For example, a pediatrician said one aspect of care that is harder to deliver well using telemedicine tools is *“anything genitourinary related if exam required.”*

Through the open-ended responses, several participants (14%) said it was more **challenging to build rapport or have a difficult conversation** through telemedicine tools. An internal medicine clinician stated that *“when discussing more sensitive topics with a new patient, can be harder to build trust and rapport.”* Some participants also found it harder to initiate conversations through telemedicine tools: *“Sometimes it is harder to ask the more personal questions.”* Clinicians may hesitate to initiate these conversations because it is more difficult to console patients through phone or video. As one pediatrician noted *“Reassuring the worried parent seems to be not fully possible.”* However, some participants (4%) found it easier to build rapport and have difficult conversations through technology. For example, a psychiatrist said, *“Traumatic or very sensitive material is easier to talk about with some patients.”* Sensitive conversations may be easier to have through telemedicine because the patient may feel more comfortable at home as illustrated by a participant who said the telemedicine appointment went well because *“The patient was more calm and cooperative because at home.”*

Internet connection and video quality also contribute to frustrations with telemedicine. Using the open-ended questions, 16% of participants mentioned **internet connectivity issues** and 15% mentioned **poor video quality**. A participant said that *“Both myself and the patient do not like the fact that the audio and video sometimes disconnect or skip.”* Poor internet and quality may be due to a lack of access to technology. A family medicine clinician stated that *“Making sure access to the technology is available to everyone Regardless of where they live is key and continuing to make sure whatever tools are developed are user friendly.”* Connectivity and resolution issues are particularly prominent in rural locations as described by one pediatrician: *“I feel paralyzed with telemed. Resolution is awful, parents have difficulty connecting because of our rural location, and most appts end up just being a phone call due to technical difficulties.”* Not only are connectivity issues a nuisance, but they can also impede a diagnosis. For example, a psychiatrist stated that *“the cognitive exam is difficult over video as one could potentially have difficulty distinguishing actual cognitive deficits from connectivity issues.”*

Additionally, 6% of participants reported via the open-ended responses that insufficient patient technological literacy makes it challenging for the patients to use telemedicine, and thus, it is more challenging for the clinician. A neurologist reported that *“some older patients are intimidated by the idea of a telemedicine visit and/or have significant trouble navigating the technology, even if we try to make the instructions as clear as possible for them.”*

4.4 Clinician-Developed Strategies to Mitigate Challenges

Many participants reported developing workarounds, or innovative strategies working with current limitations, to help mitigate the challenges of telemedicine. However, as stated through the open-ended responses, some participants reported not knowing any workarounds (10%) or that someone else, such as administrators or medical assistants, have employed workarounds (7%).

4.4.1 Strategies Used Pre-Appointment to Mitigate Telemedicine Barriers

Before the appointment, participants reported asking the patient to send pictures, asking the patient to go to the clinic to measure vitals, and contacting the patient.

Many participants (11%) reported via the open-ended responses asking the patient to send pictures ahead of time, particularly when the reason for the appointment was for a rash. This workaround helped compensate for poor video quality compared to the quality of still photographs. One pediatrician stated that they *"discovered rashes are surprisingly difficult to see on video so if able, would have parent sent in photos electronically before the visit."* However, there were some questions about protocols and patient comfort regarding sending pictures of sensitive areas, such as genitals.

Another workaround that participants (6%) employed was obtaining vitals prior to the visit, either by having the patient go into the clinic or having them take measurements (e.g. weight) at home. A pediatric cardiologist said that *"most of patients have an in person visit for vitals and cardiac testing followed by telemedicine with me the next day."* Another pediatrician stated that they have parents *"[weigh] older children at home for weight-based medications."* Several participants (7%) also reported contacting the patients prior to the appointment in order to send them forms and other material. For example, a rheumatologist said that *"we have the RAPID3 form sent to patients before their visit so we have the data for the appointment."* Participants reported contacting the patients either through text messages or through the EHR.

4.4.2 Strategies Used During Appointment to Mitigate Telemedicine Barriers

Participants also employed several strategies during their telemedicine appointments to help make their visit more effective. As reported through the open-ended responses, one strategy that clinicians are using during the appointment is having the patient use various tools (such as flashlights, magnifying glasses, and thermometers) or adjust their lighting (7%). One clinician said *"lighting is the hardest thing so one needs a good flashlight."* Other clinicians would instruct their patients on where to take the telemedicine appointment so that they had optimal lighting. For example, one clinician would tell patients to *"turn off fluorescent lights and use more natural light from windows."* Clinicians reported using other tools too, such as an otoscope attachment for a phone, to help with the physical exam.

To help clinicians with the physical exam, many asked the patients to perform self-exam activities or other activities that they could observe (10%). One clinician referred to this as *"Self directed patient exam maneuvers."* Pediatricians would also *"guid[e] parents on how to do some parts of the exam."* For example, one pediatrician *"used telehealth to walk a family through resetting a nursemaid's elbow by telehealth using my son as a 'prop' on my end and they were beyond thrilled not to have to go to the ED during the pandemic."* Other types of doctors also involved family members and caregivers. A neurologist stated that they *"ask their spouse to do a pull test to test their postural stability."* In addition to having the patient or family member perform an exam, they would also ask the patients to do certain tasks while they observed. This would help them perform parts of the exam, such as the neurological exam. For example, a neurologist reported that they are *"getting better at doing the neurologic exam virtually, for example asking the patient to do a variety of tasks like drink from a cup."*

5 DISCUSSION

Our research builds on previous findings that identify situations suitable for telemedicine, perceived benefits and barriers of telemedicine, and workarounds used to mitigate challenges caused by technology [6,10,20,29,74,80]. We also add to the literature on the widespread telemedicine use during the COVID-19 pandemic by exploring clinician opinions of telemedicine after a rapid implementation and how they are using telemedicine technology to accomplish their tasks. The results from our survey identify the specific benefits and

barriers of telemedicine that clinicians perceive and the strategies they use to make telemedicine work better for them.

Our survey identified several clinician-perceived benefits to telemedicine. One benefit to remote appointments reported by our sample was the ability to see the patient's home environment. Seeing the patient's home setting allowed them to gain more context into the patient's life. This unintended positive consequence of telemedicine has been reported briefly in other studies within the context of mental health [87] and primary care physicians [31]. Being able to see a patient's home has raised some ethical dilemmas [55], however, the glimpse into a patient's home environment could allow the doctor to better treat and care for their patient. Future research should explore how patients feel about their home being visible to their provider and whether informed consent should be collected prior to the visit.

The clinicians in our sample highlighted aspects of telemedicine related to equity. The clinicians reported that telemedicine removes some barriers to care, but they have concerns over connection issues and patient technical skills, which could prevent some patients from receiving the benefits of telemedicine. It is important that we as researchers as well as clinicians understand what structures need to be in place to support all patients' use of telemedicine or provide in-person options for patients who cannot access telemedicine. The understanding that telemedicine removes barriers to care and improves access has been echoed by previous studies [54]. It has also been reported that internet connectivity varies significantly and that lower-income neighborhoods and minority communities have the largest dead zones [66]. Additionally, vulnerable populations have different levels of technical skills and computer literacy [51]. Thus, telemedicine could be a powerful tool for improving access to care, but it is vital that we focus our efforts on ensuring that all populations have the tools, knowledge, and structures necessary to use telemedicine technology or receive equitable in-person care. Resources saved from using telemedicine for some patients could be allocated to help other patients receive in-person care. Further research is needed to identify when telemedicine is most appropriate based on the type of appointment and the patient's available resources. In the next section, we consider specific technological features that address these issues.

Another hindrance of telemedicine identified by our sample was the inability to perform a traditional physical exam. Clinicians found unique methods to perform a remote exam, such as instructing the patient to complete a self-exam or observing certain activities through the computer. But these methods are time consuming to devise and often rare. Previous papers have described best practices for conducting remote examinations. For example, Iyer and colleagues [40] detail how to perform a spine exam on elderly patients through video: ask the patient to set the phone in a hallway and take 5 to 10 steps towards the camera, turn counterclockwise and return to their starting position while observing their gait for abnormality. However, many such techniques are idiosyncratic to specific clinical assessment and need further investigation as a more broadly applicable strategy. It is important to facilitate physical exams through telemedicine because they are vital in assessment, diagnosis, screening, and prognosis [85,86]. Supporting aspects of physical examinations is a clear next step and we elaborate on this in the following section.

Despite these drawbacks, there appear to be situations where virtual visits can thrive and may even be preferred to in-person appointments. While situations requiring physical exams are still difficult to conduct remotely, our sample indicated that other situations, such as behavioral and mental health care, are appropriate for virtual visits. This is consistent with previous studies which have also outlined activities that are best suited for virtual visits. For example, a systematic review of telemedicine in urology found telemedicine works in certain

conditions (e.g. uncomplicated urinary stones and UTIs) but that more research is needed on other conditions [61]. More in-depth research is needed across all specialties to determine when telemedicine should be used and when in-person appointments are recommended.

There are existing systems that can be included as part of telemedicine tools to address some of the concerns identified by the clinicians in our example. For example, our research found that clinicians had difficulty establishing rapport and strengthening the patient-provider relationship remotely. Systems such as MeetingCoach [77] and ReflectLive [26] provide feedback to the user about their non-verbal communication, such as tone and eye contact, in order to help improve rapport. Integrating these systems with telemedicine tools could alleviate some concerns that clinicians have with telemedicine. However, there are still several concerns that need to be addressed.

Below we review opportunities for HCI and health informatics researchers to facilitate the improvement of telemedicine services and tools to support long-term adoption and use. These areas include (1) Integrating workaround strategies into deliberate telemedicine features, (2) Creating personalized automated systems for patient setup to address inaccessibility, (3) Building technologies to be used by patients with provider guidance, and (4) Disseminating strategies employed by other providers.

5.1 Integrating workaround strategies into deliberate telemedicine features

Because of the previous underutilization of telemedicine tools, it is not surprising that there was relatively low motivation to improve the design of these tools for everyday use. So in order for clinicians to use telemedicine tools, they have developed workarounds. Workarounds are behaviors that “circumvent or temporarily ‘fix’ an evident or perceived workflow block” [20]. Workarounds are extremely common within healthcare settings [46,92]. Some clinicians even view workarounds as the only way to accomplish their work [58]. Examples of workarounds used in a healthcare setting are writing patient information on paper instead of directly into the computer system [7] and scanning a patient barcode on a sticker instead of the barcode on the patient’s wristband [45].

Workarounds are developed to solve a variety of problems, including poor workflows, organizational and system issues, and inadequate technology. The participants in our sample used workarounds to improve their ability to perform an examination (e.g. instructing the patient on how to perform examination techniques) and for solving technical issues (e.g. asking the patient to send pictures prior to the virtual appointment because of poor video quality). The clinicians who created these workarounds, also known as Lead Users [36], understand what needs currently exist and will persist in the future, and thus are good sources of information when designing new tools.

Knowledge of workarounds and practices performed by Lead Users can provide insight into technologies that do not support processes and issues that need to be resolved [7,90]. These insights can be used to inform the design and development of technology [18], which allows for a bottom-up involvement where the users’ actual workflow and environment are taken into consideration and the users play a role in the design of the system [4,7]. This is especially important in healthcare because the work is highly complex and issues could lead to serious consequences [2,18].

Workarounds will only be developed when the system is in active use and the users are familiar with the system [2,36,62]. Thus, the rapid employment and use of telemedicine during the COVID-19 pandemic affords us the opportunity to learn about unmet needs and the corresponding workarounds, which will allow us to better

design telemedicine for long-term use beyond the COVID-19 pandemic. Understanding workarounds used during the pandemic and integrating those strategies into features of the tool will lead to telemedicine tools that are more appropriate for long-term use. In the next two sections, we describe technological opportunities that could improve the telemedicine experience. These opportunities and design recommendations are drawn from the unmet needs and workarounds described by the clinicians in our sample.

5.2 Creating personalized automated systems for patient setup to address inaccessibility

A common challenge identified in our research was the patient having an inadequate setup for the telemedicine appointment. Specifically, clinicians reported that patients did not have strong enough internet connection, poor video quality, and insufficient lighting. To solve these issues, the current workarounds employed by clinicians involve asking the patient to use a flashlight or move to an area with natural light or switching to a phone call if the video quality or internet connection fails. To address these challenges, previous researchers have suggested that a technical liaison assists the patients before the appointment to ensure the patient is able to use the telemedicine platform and has the necessary technologies [14] or that clinics distribute fliers with instructions and frequently asked questions [69].

To complement existing approaches, we propose that an automated system is built, to help the patient get sufficiently set up for a telemedicine appointment. This automated system could check that the patient's setup has adequate audio, video, lighting, and connection. If the automated system detects that the patient's setup is not sufficient, it could recommend solutions or connect the patient with resources that could help. This system would remove the burden from clinicians and allow them to focus on more pertinent patient care. There are existing technologies and programs that evaluate a person's internet connection (e.g. Measurement Lab [23]) and audio and video quality (e.g. Video Clarity [89]), but to our knowledge, these tools have not been utilized in the healthcare space. The addition of these automated programs into the telemedicine appointment workflow, along with a novel tool that checks for sufficient lighting, would improve the patient and clinician experience of telemedicine tools.

New technologies and health informatics interventions can exacerbate existing healthcare disparities. Veinot and colleagues [88] propose a model for how health informatics intervention can create inequality. They state that an intervention "*produces inequality if it is (a) more accessible to, (b) adopted more frequently by, (c) adhered to more closely by, or (d) more effective in socioeconomically advantaged groups such as those with more resources or education*" (p. 1081). An automated tool that identifies whether the patient has adequate technology and is in an adequate environment for remote care and can suggest local resources may help improve healthcare equity. This tool may help reduce inequality in the accessibility, adoption, and adherence of telemedicine and remote care. Currently, if a patient does not have the appropriate technology or internet connection to access telemedicine care, troubleshooting occurs during the appointment, which reduces the amount of time the clinician has to treat and talk with the patient, or the appointment fails to happen. By troubleshooting technology and setup issues beforehand and allowing the patient time to connect with local resources if necessary, the patient will receive more thorough care and the burden will not be placed on the clinician.

5.3 Building technologies to be used by patients with provider guidance

To make telemedicine an effective alternative for a broader range of appointments, patients will need to collect vitals and other information to provide to their clinician. Many clinicians in our sample reported that the patients would collect some measurements using tools they had at home, such as using a scale to measure their weight or a blood pressure cuff to measure their blood pressure. This opens the door to more advanced tools that could be used by the patient during virtual visits with guidance or supervision from the clinician. Until now, tools and medical devices are either meant for use by the patient or by professionals. With the increasing prevalence of telemedicine, there is opportunity for activities to be performed with tools by a patient with remote collaboration from a clinician.

Tools to support remote collaboration on physical tasks have been designed and studied in other contexts. For example, one study examined collaboration on building a toy robot with one person who actively did the work and another person who helped the worker by providing guidance remotely [28]. The study compared different video angles and found that when the camera showed the view of the workspace and the worker's hands the task was completed significantly faster compared with audio only and a head-mounted camera with eye tracking. Using a camera that shows enough visual information may be sufficient for a clinician to instruct a patient on using tools that would gather information necessary for making a diagnosis. This may alleviate the difficulty in conducting a physical exam virtually and may make telemedicine even more advantageous.

5.4 Disseminating strategies employed by other providers

The biggest challenge reported by clinicians to using telemedicine is the difficulty in performing a physical exam. Some providers have been able to think of strategies that help them perform the exam through telemedicine tools, such as instructing the patient on performing self-exam maneuvers and observing the patient as they complete certain activities. However, not all providers have been able to think of these activities. Previous reports have instructed clinicians to “brainstorm what parts of the physical examination can be performed by video” [14]. However, we understand this is a difficult and time-consuming exercise. Thus, we are proposing that these ideas are shared and disseminated so the burden is not on the individual clinician but on the entire community.

We suggest that providers share their ideas and learn from other providers about ways to perform a physical exam through telemedicine tools. A crowdsourcing platform could facilitate this knowledge exchange. Crowdsourcing is used in other aspects of healthcare. For example, it is commonly used among patients to share treatment, symptom, and outcome information [13]. A previous study that measured the acceptability of crowdsourcing by providers found that the majority of clinicians surveyed believed that crowdsourcing would be useful for diagnosing unusual cases, referring patients, and problem-solving at the point of care [82]. Thus, crowdsourcing is a promising avenue. The findings from this present study suggest that a system that allows clinicians to share ideas of activities they can observe through video to help with diagnosing would improve the effectiveness of telemedicine tools.

6 LIMITATIONS

Although our sample size was strong given the existing stress on health care workers, our sample size was small across various specialties and countries, and different opinions and perspectives may be discovered in a larger population. Our survey also represents opinions from a two-month period, and it is possible that

perceptions have changed as the pandemic continued to evolve. Future work should explore telemedicine use in a variety of settings and situations. Additionally, while self-reported data is a valuable method of data collection, especially during social distancing orders, an ethnographic study would provide rich information on workarounds and the use of telemedicine by clinician. Despite these limitations, this study can guide researchers and technology designers in health care going forward and lead to the expansion of telemedicine in practice.

7 CONCLUSION

In this paper, we report the findings from a survey of 105 clinicians about their telemedicine use, situations they believe are appropriate for telemedicine, perceived benefits and challenges to telemedicine, and workarounds created and employed. This survey was conducted about three months after the start of the COVID-19 pandemic and the wide-spread implementation of telemedicine tools, which allowed us to explore how telemedicine is used in daily practice. Our results provide insights into aspects of telemedicine that could be improved and would make telemedicine tools more appropriate for everyday virtual visits. By understanding clinician perceptions of telemedicine and what workarounds they are currently employing, we are able provide technological and design recommendations that would improve the experience of telemedicine tools for clinicians and patients. The use of workarounds highlights the need to use participatory and co-design strategies when designing telemedicine tools so that staff workflows and opinions are better supported. Additionally, understanding appropriate uses for virtual visits and the drawbacks of telemedicine tools will allow us to make these systems more equitable. Virtual visits may be the 'new normal' for healthcare, so it is important that we rapidly implement what we have learned thus far so that we can improve the telemedicine experience and prepare for its long-term use.

ACKNOWLEDGMENTS

[Blinded for review]

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