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Understanding older adults' perceptions and attitudes towards a telehealth robot

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Abstract

Background: With the growth in the aging population and caregivers who need health-care support, telehealth tools such as assistive robots are emerging as feasible options to augment care for older adults. Telehealth robots provide a medium for healthcare personnel and/or caregivers to remotely carry out healthcare tasks without requiring the care recipient to commute to the healthcare center or for the caregiver to travel to the recipient's home. However, current telehealth robots are not fully functional or adaptable for some of these tasks and use case scenarios. Moreover, for the care of older adults, the perceptions, preferences, and attitudes of the older adults are not factored into the design of the robots to make them usable and useful for them. A deeper understanding of their needs, perceptions, and disposition towards telehealth robots is required.
Research Aim: This research investigated older adults' perceptions and attitudes toward a telehealth robot supporting their health checkups at home.
Methods: We conducted a mixed-methods study with ten older adults to understand their perceptions of telehealth robots in a home environment. We showed them videos of the robot prototype carrying out healthcare tasks and assessed their perceptions about this type of robot in their home and other use cases that they would envisage.
Results: The older adults conveyed overall positive first impressions towards the safety and flexibility of the soft robotic arm capabilities. Some participants who had negative views of the robot still found them useful, diligent, capable, and accurate.
Conclusion: This research allowed us to investigate older adults' perceptions and attitudes towards a novel telehealth robot. We identified a broad range of preferences and potential healthcare use cases to guide design requirements for robots in telehealth contexts.

Keywords: Assistive robot, older adults, human-robot interaction, healthcare robots, telemedicine

Introduction

Imagine a post-surgical outpatient recovering at home, requiring a weekly checkup but living miles away from the healthcare center. A strategy to manage care in this situation would be to have a telehealth robot situated at the patient's home, remotely controlled by the physician to perform routine checkups, inspect the incision site, and perform various forms of auscultation needed. This is not yet the norm. Outpatients in such situations would love to enjoy such convenience, but some do not have reliable access to a nearby healthcare center or a physician (Silvera-Tawil, 2024). A significant percentage of these patients are older adults who live alone (approximately 30% are over age 65; 39% are 85 years and older; Hung et al., 2022) and who do not have a family care partner and or professional caregiver to support them (Boot et al., 2020). Though not all older adults are in this situation, there are many with minimal access to quality healthcare whose needs have not been well represented, documented, or addressed (Veling & Villing, 2024). The goal is to make such health-care access available to as many older adults as possible, and telehealth robots could be a feasible solution to advance that goal.

As part of the US National Academy of Medicine's Vital Directions for Health and Health Care initiative, guidance was provided to actualizing better health and healthcare to a more significant percentage of older adults who do not have access to quality healthcare (Rowe et al., 2016). Part of the directions highlighted was the development of new approaches to care delivery as a vital priority to improve the care and quality of life for all older people (Fulmer et al., 2021). This includes the integration of novel telehealth solutions, such as telehealth robots, into existing and new healthcare practice models (Kavedzija, 2020) to augment care for older adults. The benefits of such a telehealth robot for older adults include overall healthcare cost reduction, access to healthcare professionals, improved care quality, and services beyond other telehealth devices. It includes making mobility and manipulation capabilities possible

Table 1. Sociodemographic characteristics of participants in the sample

Baseline characteristic	*n*	%
Gender		
Female	5	50
Male	5	50
Ethnicity		
White / Caucasian	10	100
Highest Education Level		
Bachelor's Degree (BA, BS)	6	60
Master's Degree (or other post-graduate training)	2	20
Doctoral Degree (Ph.D., M.D., Ed.D., D.D.S., J.D., etc.)	2	20
Marital Status		
Single	2	20
Married	7	70
Divorced	1	10
Living Situation		
Living alone	2	20
Living with a Spouse or Partner	8	80
Income Category (Annual, US$)		
25,000 – 49,999	1	10
50,000 – 74,999	1	10
75,000 or more	5	50
Do not wish to answer	1	10
Do not know for certain	2	20
Health status (Self-report)		
Good	4	40
Very good	2	20
Excellent	4	40
Chronic health conditions		
None	0	0
Arthritis	2	20
Diabetes	3	30
Heart condition	1	10
High cholesterol	1	10
Hypertension	3	30

during remote monitoring and care, along with non-invasive tools to garner on-demand high-quality videos and images for diagnosis and treatment (Dagioglou et al., 2014; Kadylak et al., 2023). Additionally, these robots can facilitate reaching older adults who live alone, have limited transportation options, or are in distant, rural communities, thereby improving the efficiency of care delivery (Garfan et al., 2021).

Despite the advancements of telehealth systems in recent years (Sobrepera et al., 2024), there remain challenges regarding the deployment of telehealth robots for the care of older adults (Olatunji, et al., 2022; Céspedes, et al., 2021) such as perceived risks to privacy and security, potential challenges with ease of use (Scott et al., 2022; Sousa et al., 2021), as well as potential misuse and disuse of the robot (Hung et al., 2022). All these factors point to a need for a deeper dive into understanding the needs of older adults; their characteristics, perceptions, experiences, and concerns about these telehealth robots, and potential ways they would like these robots to support them. Therefore, we investigated older adults' perceptions and attitudes toward a telehealth robot supporting their health checkups at home. Insights gained will help refine the focus of telehealth robot developments to truly meet the needs of older adults and improve their access to quality healthcare on a greater scale.

Methods

Participants, recruitment, and data collection

We recruited 10 older adults (see *Table 1*), age ranges of 66 to 73 years old (mean age 67.7, SD=3.40), and split evenly across both genders. Our sample was recruited through emails and flyers using the snowball sampling method (Naderifar et al., 2017). All recruitment and study procedures were approved by the Institutional Review Board at the University where the research was conducted. Participants were screened using the modified Telephone Interview for Cognitive Status (TICS-M; Cook et al., 2009) to ensure they had no cognitive impairment (TICS-M Score 31 or higher).

Materials and measures

We used quantitative and qualitative study materials, including questionnaires, robot demonstration videos, and interview scripts. These materials are described as follows:

Questionnaires

The questionnaires were administered before the robot demonstration video was shown and after the structured interview was conducted. We assessed sociodemographic information through a background questionnaire (TechSAge Background Questionnaire; Remillard et al., 2020), which was also used to assess health, memory, and any sensory or functional limitations. We assessed their familiarity with robots using a Robot Familiarity and Use Questionnaire (Mitzner et al., 2015) that featured 13 types of robots (e.g., entertainment, surgical, and telepresence robots) with response options 1 (not sure what this is) to 5 (have used or operated this robot frequently). The Robot Trust Questionnaire (Ullman & Malle, 2018) was administered to evaluate their level of agreement with statements related to comfort, reliance, and capability of the telehealth robot on a scale from 1 (strongly disagree) to 5 (strongly agree).

Robot prototype and apparatus

We developed a prototype of the robot and demonstrated the capabilities of the robot to show participants through video recordings. This prototype was used in a companion study wherein we interviewed healthcare providers about the potential of this type of telehealth robot (see Kadylak et al., 2023). The initial design included several aspects of the robot: rigid link arm, hybrid rigid-soft final link, end effector camera, and software architecture, as detailed below and illustrated in *Figure 1*. The 3-link rigid arm has 3 high torque capacity servos (Hitec D950 TW) at the joint locations labeled J1, J2, and J3 in *Figure 1*. The links J1-J3 help to position the final link J4

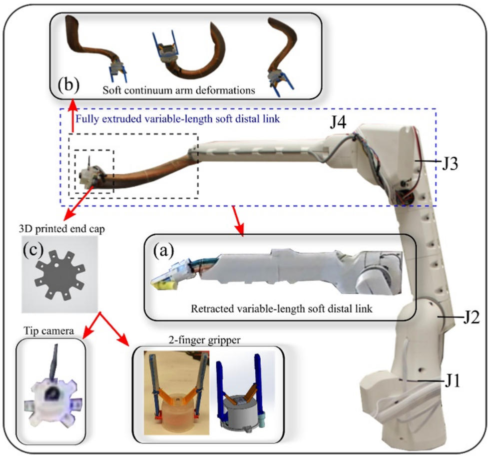

Figure 1. Hybrid rigid-soft robot components. Note. (a) Retracted variable length soft distal link that can extrude the soft continuum arm (Uppalapati et al., 2020), (b) three examples of spatial configurations of the soft continuum arm; (c) 3D printed end cap that can connect to a tip camera or a 2-finger gripper. J1-J4 illustrate arm joints (degrees of freedom). The dotted box includes a system component that could be mounted on any other platform. (Reprinted from Kadylak et al., 2023.)

in the position desired. The final link is a hybrid of rigid and soft materials. A soft continuum arm (SCA) is nested inside the hollow rigid cylinder and can extrude out or retract into the cylinder as needed. Research has shown the safety of these soft arms when interacting with soft, fragile objects and humans (Ku et al., 2024). The SCA provides several degrees of freedom in bending and rotation for clockwise and counterclockwise motions. At the tip of the SCA, a wireless camera (600TVL 1/3 CMOS Micro AIO FPV Camera) or a 2-finger gripper could be attached, as shown in *Figure 2*. The camera transmits the video feed

Figure 2. The RTLS tag in comparison to the size of a micro SD card. In an indoor space the location of the UWB tag (B) is determined by calculating the difference between the time of arrival of the wireless signal from the tag.

using a 5.8 GHz, 40-channel video transmitter. The receiver on the robot helps to capture, view, and save the video. The robot runs on a Robot Operating System (ROS) platform - ROS Melodic version and is programmed with Python through a Raspberry Pi 4B. The robot was preprogrammed to carry the tasks shown in the videos to the older adults.

Robot demonstration video

Participants were shown a 4-minute narrated video to introduce the robot prototype. The video was developed and recorded in the McKechnie Family LIFE Home, which is a home simulation space. This video presentation marked the initial stage of the study, designed to gather participants' reactions and perceptions before they interacted directly with the robot. We illustrated the robot performing different tasks with a narration that explained a series of seven different tasks that were autonomously performed by the soft robotic arm, as illustrated in *Figure 2*: (a) body scan; (b) horizontal band-aid scan, zooming on a region; (c) impact absorption by the soft robotic arm; (d) upper-body scans; (e) medication management; and (f) wound care. We started with a representative set of tasks to get older adults' perceptions about these tasks and their perceptions about other potential tasks to which we should extend the robot's design. This approach is a valuable method to explore users' perceptions and preferences to extend the range of applications in future design iterations.

Interview script

The structured interview assessed older adults' perceptions of the potential for a soft robotic arm for telehealth and engaged them about the specific prototype and tasks shown in the video. Specifically, participants were asked about their overall impressions, ideas for how the robot might be used for telehealth tasks, usability and adoption barriers, environmental issues, control preferences, and aspects of human-robot trust (see sample questions in *Table 2*).

Procedure

The study flow is illustrated in *Figure 3*. We conducted remote interviews with older adults using Zoom video conferencing. Prior to data collection, participants reviewed IRB-approved informed consent documentation and then verbally agreed to participate in the study. The data collection began with the TechSAge Background Questionnaire (Remillard et al., 2020), followed by the Robot Familiarity and Use Questionnaire (Mitzner et al., 2015). After the introductory information about telehealth and robotics was provided to the older adults, the demonstration videos were presented to the participants, followed by semi-structured interviews. At the end

Table 2. Sample of the interview questions and the different aspects the questions focused on

Topic	Interview questions
First impressions	What might be the most useful application for this type of robot?
Privacy	Would you be comfortable if the robot monitors you on a regular basis? For example, if it checks up on you twice a day?
Control/user-interface	In what types of situations do you see yourself needing to control the robot?
Communication	How would you want to communicate with the robot?
System feedback	How would you want the robot to communicate with you? How would you want the robot to communicate that it is turned on or recording?
Other home tasks	Can you think of other tasks that this type of robot could help you with in your home?
Robot appearance	Would you want this type of robot to have a friendly personality?
Robot safety	Would you be comfortable with the robot touching you during different tasks, such as wound care, stethoscope reading, or blood pressure monitoring?
Trust	Would you trust the robot more if a healthcare provider was controlling the robot, or if the robot was performing a task completely on its own?

of the semi-structured interviews, the participants completed the Robot Trust Questionnaire (Ullman & Malle, 2018). Participants were then offered a $25 Amazon eCode gift card as compensation. Each interview lasted approximately thirty minutes.

Analytical procedures

We conducted descriptive data analysis for the questionnaire data. The interview audio transcriptions were transcribed verbatim, and we used inductive qualitative coding procedures (Blocker et al., 2020; Braun & Clarke, 2006; Charmaz et al., 2012) to examine emerging themes in the responses provided by the participants. The goal was to identify the most salient themes relating to the reactions of the older adults towards the robot, their intention to use it, and any concerns they had about it. We iteratively addressed and synthesized the emerging sub-themes to minimize discrepancy and redundancy. The emerging themes were then translated into design requirements and technical expectations for the design team.

Results and discussion

Overall impression of the older adults

Most of the older adults conveyed overall positive first impressions towards the robot. Seven of the older adults commended the flexibility of the soft robotic arm. The three participants who had negative views of the robot still found it to be useful, diligent, capable, and accurate. Key adjectives used to describe soft robots were impersonal, functional, and utilitarian. Some participants reported seeing added value in the robot system for other individuals in their life, including conditions with end of life, people who just got home from hospitalizations, people experiencing heart conditions, people who just got discharged from traumatic injuries, people with memory with disorders, and memory care patients. For example, one older adult stated: "I can see this happening in the future there's more people needing help, especially with the baby boom and our providers, it's going to get really essential that we have more tools like this to help manage that because there's going to be a lot of people with a lot of conditions coming up in the generation as we age into our 80s and 90s."

Another stated: "My 101-year-old neighbor…for her to get an appointment and get to the doctor's office is a real problem…especially during this pandemic…getting her dressed up right and getting out the door into her car to the waiting room, going through all that and then getting to the doctor I mean for her time isn't a big issue, but it's just the discomfort of doing all that."

Intention to use

Most of the older adults expressed willingness to use the robot. Seven commented on the functionality of the robot. They discussed various uses for the robot in addition to the examples shown in the robot videos. Regarding end-effector attachments, a few participants were concerned about the ease of changing the end-effector attachments manually if another tool was required. They also sought to know more about the robot's navigation, such as the robot getting up the stairs. Regarding auscultation, most of the older adults mentioned that their healthcare provider usually listened from the back in addition to the chest and inquired as to how the robot would do that. Five of the participants wished the robot could be augmented with some form of entertainment, such as playing chess, cards, or telling jokes. Two of the participants desired that the robot could support medication management. These participants stated that many older adults they knew use a weekly pill organizer and inquired on the possibility of the robot helping such function in the scenario. In terms of communication with the robot, most of the participants preferred direct voice commands to control and commu-

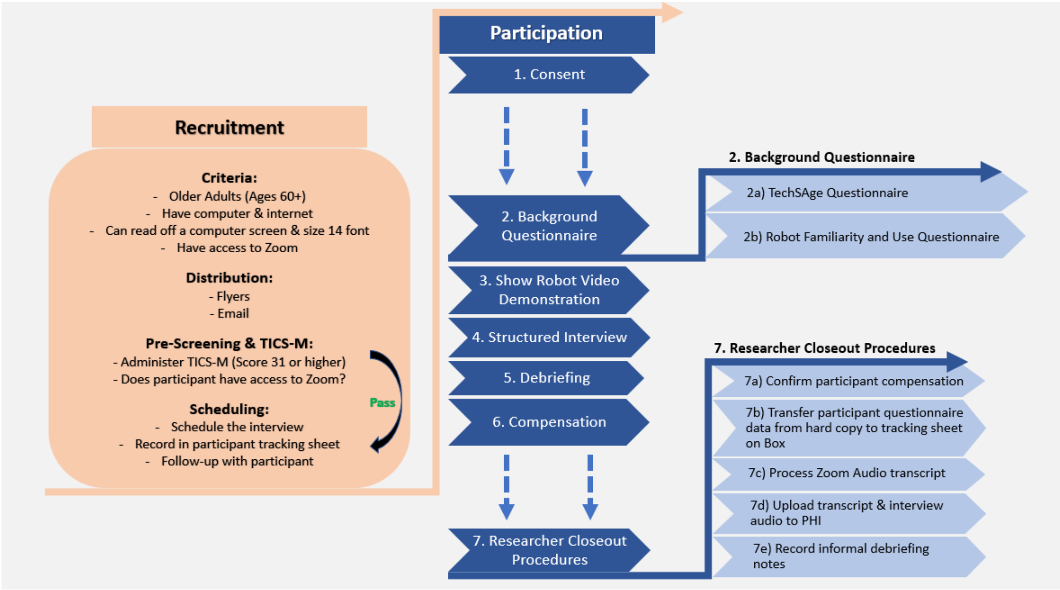

Figure 3. Study flow diagram

nicate with the robot. They suggested having a "safe word" that triggered the robot to cease operations at any moment to maintain their autonomy. One participant suggested: "Maybe the robot can make announcements that it is intending to begin performing a task?"

Willingness to trust the robot

Most of the participants expressed a high level of trust in the telehealth system. In three of the four questions asked about trust based on perceived capability of the robot, most of the participants indicated agreement with the positively framed statements. Half of the total participants agreed with the statement – "I would find this telehealth robot to be accurate." None of the participants disagreed about it. Seven of the participants indicated in the trust questionnaire that they would be comfortable with having the telehealth robot in their homes. They also said they would be comfortable with their healthcare provider remotely controlling the telehealth robot. Seven agreed with the statement, "I would count on this telehealth robot."

Concerns

Several of the participants expressed concerns about the appearance of the robot. Even though it was stated categorically that the robot was in the prototype form and attention should be more on functionality than appearance, some participants still expressed their concerns. For instance, some commented that the soft robot arm reminded them of a snake or reptile and may cause uneasy feelings. Four of the participants wanted the robot to have a friendly personality and even wished for it to have a name, costume, or animal-like design, whereas others did not think it could have a friendly personality.

Additionally, five of the participants raised concerns relating to the privacy and security of their health information against cyber threats. The issues that were raised with respect to the security of the robot or health information protection point to the importance of ensuring that data collected by a telehealth robot is kept secure and private. We also identified the need for instructional support to help users understand the measures that have been put in place against cyber security threats and attacks. Transparency for users should be prioritized in the design to inform users of data being captured, when and where, and to provide autonomy, options, and control for users to decide what information they want to be captured. This includes access for the user to stop monitoring or recording if needed.

Main themes emerging

A summary of the emerging themes is organized in *Table 3* for different aspects of the design, such as functionality, communication, control, appearance, privacy, system feedback, trust, safety, and use for home tasks. The facilitators and barriers to adopting the telehealth robot emerging from the study are included as they relate to the themes. We highlight design insights that would inform the design of telehealth robots to ensure they meet the needs of older adults.

Limitations

This study was composed of a small and homogenous sample; as such, the opinions might not be representative of all older adults. This is

Table 3. Themes emerging from the study along with barriers, concerns of the older adults and applications for robot development

Aspect	Emerging themes	Barriers and concerns	Application for robot development
Privacy	Security and data privacy Need for instructional support	Cyber security threats Keeping the privacy of medication management	Non-hackable security Transparency for users regarding what is being recorded, when and where. Access for the user to stop monitoring or recording if needed
Control and user interface	User control options Mixed autonomy for control	Stopping the robot in case of errors or possible harm Access to some form of control of the robot for specific functions	Autonomous controls for manipulation and navigation Manual override if needed. Allow control for patient and health providers (emergency control override)
Communication	Importance of voice communication with robot Multimodal communication for flexibility	Desire to communicate with the robot by voice. Large screens for visual communication	Options for communication by touch screen, voice, keypads Accommodate for the differing technology literacy levels among older adults
System feedback	Importance of audible and visual notifications Visibility of robot status Management by consent	Audible communication from robot Standard greeting from robot when turned on. Statements / alerts by robot before it performs a task. Combining visual and audial alerts and feedbacks	Variety of alerts from robots to accommodate variability in ability levels. Screens, LEDs, speakers, vibrations can be used in hybrid mode
Robot appearance	Desire for personalization	Curiosity about size – would it fit into home spaces. Possibility for personalization of color, size, feedback Snake-like form of the soft arm	Cover all exposed areas of the robot that can harm both the robot or the patient Make the robot more aesthetically pleasing to make it more personable
Safety	Managing trip/fall hazards Risk mitigation and patient safety	Concerns with touch during wound care	Include fail-safe mechanisms (e.g., 'safe word' or button for retracting the robot)
Trust	HCP in the loop as much as possible Willingness to use the robot later in the future	Availability of the HCP to support with control if needed	Prepare potential use cases for future interactions
Home tasks	Utility of robots beyond medical tasks Hedonic motivation to use Entertainment and social interaction and engagement	Picking up dropped items. Reinforcing utility for other home tasks	Improve grabbing to help with holding, picking, and placing tasks. Improve navigation around the home to help with fetching. Possibility of changing end-effector if needed

ongoing research, where we first evaluate older adults' perceptions and attitudes towards a telehealth robot supporting their health checkups at home. Nevertheless, the insights gained inform the focus of telehealth robot developments for further study and provide guidance for the design of telehealth robots more generally. The findings highlight the needs of older adults that should be addressed to improve quality healthcare through telehealth robots.

Conclusion

This research allowed us to investigate older adults' perceptions and attitudes towards a novel telehealth robot. One of the main challenges that inspired the research included identifying the factors that influenced the deployment of telehealth robots to support older adults (Rowe et al., 2016). We know from the literature that a lack of understanding of the needs of older adults in this home healthcare context is one factor that affects the widespread use and adoption of several technologies (Boot et al., 2020). In the context of assistive robotic support, scholars have raised concerns about the tendency to ascribe general needs to older people based on societal factors such as aging demographics rather than the specific, actual, and situated needs of real people (Frennert & Östlund, 2014; Neven, 2010). This approach tends towards a 'deficit' model of aging as a series of losses, expressed in physical decline, cognitive declivity, and social isolation rather than people's abilities, in a more supportive and developmental way (Lee & Riek, 2023). This study allowed us to understand in a comprehensive manner the needs of older adults in a broader sense and a defined home healthcare context. Their preferences and potential healthcare use cases helped to elicit further design requirements for robots to be used in telehealth contexts.

In general, developing useful robots for older adults is more than simply creating robots that complete tasks. Careful consideration must be given to the users' abilities and concerns as we develop the robot's capabilities to meet their needs (Beer et al., 2015). In this study we observed a variety of needs and abilities the robot could support. We learned about the peculiarities of perceived risks to their privacy and security in this context, which could be potential barriers to adoption, as emphasized by (Sousa et al., 2021; Scott et al., 2022). We highlighted some design insights to surmount some of these challenges.

Although most of the older adults we interviewed had little or no exposure or familiarity with robots, they were generally open to the concept of having and using the telehealth robot. This relates to some of the outcomes of the broader literature revealing the openness of older adults to robots supporting everyday activities in general (Smarr et al., 2012). The individual reactions of the older adults were overall positive, and they expressed intentions to use the robot when it became available. Their reactions align with those of healthcare practitioners who have shown interest and willingness to use such telehealth robots (Kadylak, et al., 2023). These underlying user acceptance factors impact the actual use and eventual acceptance of the technology (Davis, 1989; Hung et al., 2022). The thoughts expressed regarding other uses of the combination of the soft and rigid parts of the telehealth robot have broadened the use cases for the robot and increased the potential utility of the robot. The older adults drew attention to other assistive functions in the house (e.g., delivery, safety monitoring) that the robot could support in addition to the main telehealth tasks it was designed for. The concerns they brought up yielded design recommendations that can be used to improve telehealth robots' capabilities, security, and usability. Future research would benefit from the connectivity of such robots with other existing smart home technologies, such as digital voice assistants that could provide older adults and remote healthcare personnel with easier control of the robot. As more sensors and smart appliances are being integrated into homes, the vision is to have them interconnected with the telehealth robot to provide easier access, flexibility, and ease of use for older adults of all ages and abilities.

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