"My Hand Doesn't Listen to Me!": Adoption and Evaluation of a Communication Technology for the 'Oldest Old'

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ABSTRACT

Adoption and use of novel technology by the institutionalized 'oldest old' (80+) is understudied. This population is the fastest growing demographic group in developed countries, providing design opportunities and challenges for HCI. Since the recruitment of oldest old people is challenging, research tends to focus on older adults (65+) and their use of and attitudes towards existing communication technologies, or on their caregivers and social ties. Our study deployed a novel communication appliance among five frail oldest old people living in a long-term care facility, which included field observations and usability and accessibility tests. Our findings suggest factors that facilitate and hinder the adoption of communication technologies, such as social, attitudinal, digital literacy, physical, and usability. We also discuss issues that arise in studying technology adoption by the oldest old, including usability and accessibility testing, and suggest solutions that may be helpful to HCI researchers working with this population.

ACM CLASSIFICATION KEYWORDS

H.5.2 [User Interfaces]: Evaluation/Methodology, User-centered design. K.4.2 [Social Issues]: Handicapped persons/special needs.

AUTHOR KEYWORDS

Oldest old; communication technologies; adoption; evaluation; usability; accessibility; methodology.

INTRODUCTION

The 'oldest old', people over 80 years of age, are the fastest growing demographic group in developed countries [35, 1]. According to recent demographic projections, this age group will account for 19% of the global population in 2050: i.e., approximately 400 million people [36]. This demographic trend presents both design opportunities and challenges for human-computer interaction. For instance, the interest in communication technologies to enable social interaction and connectedness among older adults (aged 65+) is increasing in the HCI community [2]. However, the oldest old are still an understudied population in the field, particularly those living in institutional settings, such as long-term care facilities (nursing homes).

Living in long-term care facilities is one of the top factors that may put older adults at risk of social isolation and loneliness, because of reduced interaction with social networks [6]. Thus, communication technologies can help older adults overcome the physical barriers of interacting with their social networks [10]. In addition, recent literature suggests that communication technologies can enhance active aging and sense of independence in older adults [29]. Therefore, designing communication technologies for institutionalized oldest old is critical because this group is at high risk of social isolation, loneliness, and lack of independence. Oldest old people that experience social isolation and loneliness are more likely to suffer from depression, stress, cognitive decline, morbidity, and mortality [3].

In this context, we developed a digital communication appliance for older adults living in environments associated with social isolation and loneliness. Our appliance, InTouch, is an accessible software application (currently running on Android-based tablets) that has a non-language specific interface (based on icons) and supports asynchronous communication (see Figures 1 and 2). No typing is required, only tapping or swiping, since it was developed for older adults with dexterity problems resulting from motor impairments. It allows older adults to send "waves" (pre-set "I'm thinking of you" messages) to family

Figure 1: The InTouch interface, showing the four message options: video, picture, audio and 'wave'.

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Figure 2: A participant using InTouch.

members and friends, and also photo, voice, and video messages. They can also receive photos, text, voice, and video messages sent by family members and friends. It follows the design of "communication appliances for intimate social networks" [25] and several iterations of field studies and prototype design and deployment [3].

This study examines factors for adoption and use of this communication technology among five oldest old living in a long-term care facility. Since our appliance is icon-based, we tested it with a Canadian-based cultural group whose first language is Chinese. Our findings show factors that facilitate and hinder adoption and use. We also discuss technology evaluation with this population (e.g., recruitment, training, and usability and accessibility testing), suggesting solutions for some of the problems we encountered.

RELATED WORK

How and why people adopt new technologies is a key issue for researchers and designers. Several models of technology adoption exist in the literature [15, 11, 20, 39], but most consider adoption in the workplace. Nonetheless, the 'Technology Acceptance Model' (TAM) developed by Davis (1985) has been applied outside of workplace studies and has become a common model for predicting system use [4, 8]. TAM contains three main indicators: 'Perceived Usefulness', 'Perceived Ease-of-Use', and 'Attitude Toward Using/Behavioral Intention' [11, 8]. Despite some criticisms on accounts of weak theoretical frameworks and simplistic deterministic relationships, it continues to be used as a baseline model [4, 8, 20]. TAM has also been used in the study of older adults and their adoption of communication technologies [29].

Although several studies focus on the adoption of communication technology among older adults, most investigate their use of and attitudes towards existing technology (i.e., phone, email, Skype, etc.). Research shows that weighing the perceived costs and benefits is one of the main factors for adoption: for instance, many non-computer users perceive the costs to be too great to compensate for the benefits of using newer communication technology [9, 26, 32]. But older adults who adopted email perceived the greatest benefit as being able to keep in touch with family, supplementing visits and phone calls [9, 14, 26, 32]. The ability of email to bridge time zones and distance was also an important perceived benefit [14, 23, 26]. Another major factor for the adoption of current technology is the desire to be included in family interaction, which leads many older users to adapt to the communication methods of their close ties [9, 23, 30]. For example, many participants in [32, 30] used Skype to keep in touch with young grandchildren. Yet, these findings apply to older adults (65+) in general and do not specifically address the oldest old.

The study of adoption of novel technologies among the oldest old is lacking in the literature. A few studies, however, explored the perceptions of older adults towards novel communication technology. These studies have mainly focused on the design phase, since participatory design with older adults has great potential for facilitating their adoption [24, 37, 40, 41]. In addition, much of the literature targets caregivers and family members: for example, reports on devices that enable monitoring older adults' well-being have explored acceptance by the social unit in general rather than the older adult [5, 10, 22, 28, 42]. In one notable exception, Lindley investigated older adults attitudes and use of a novel technology, concluding that convenience, asynchronicity, the informal conversational aspect of the technology, direct contact with grandchildren, and their ability to be creative were factors for adoption. Nonetheless, other factors such as the usability of the device were not investigated [22]. Usability factors seem to be relevant for adoption, because research shows that the 'fear' or 'anxiety' expressed by older adults does not result from technophobia but from lack of digital literacy [9, 29].

RESEARCH QUESTIONS

We contribute to the aforementioned literature by examining how an understudied population (oldest old people living in an institutionalized setting) adopts and uses a novel communication technology. This study expands upon prior work [3], which included interviews about general communication patterns of older adults living in a variety of sites, two probes introducing early prototype communication appliances, and the use of a first version of InTouch by a female older adult living in a retirement residence.

In this paper, we report on our new deployment of InTouch with five oldest old individuals living in a long-term care facility. This study is guided by the following research questions:

RQ1 What facilitates the adoption of a communication appliance among institutionalized oldest old people?

RQ2 What hinders the adoption of a communication appliance among institutionalized oldest old people?

The unique characteristics of our user group (frail and low-digital literacy oldest old living in institutionalized settings) presented significant challenges in selecting appropriate evaluation methods. Therefore, this paper also contributes to the literature on human-computer interaction by discussing those challenges, ranging from recruitment and training to usability and accessibility testing with this population. For example, although Dickinson et al. [13] suggest ways of adapting usability tests to older adults, the suggestions were not sufficient to overcome the challenges we encountered when selecting and conducting an appropriate usability and accessibility testing technique. Thus, we describe our challenges and advance possible solutions in order to answer:

RQ3 How to conduct technology evaluation with the oldest old?

Our study sheds light on a specific group of users (their perceptions, meanings, and contexts) and provides insight into research and design opportunities that helps refine our understanding of design implications for seniors, complementing our previous work [3]. This is reflected in a set of extended and refined considerations for the design of elder-centric technologies (numbered as **Di** throughout the paper) and for the evaluation of such technologies (numbered as **Ei**).

METHODS

To explore factors that facilitate and hinder the adoption of communication technology amongst this understudied population, we conducted a two-month deployment of InTouch with five residents of a long-term care facility in Toronto, Canada. Following a mixed methods approach (i.e., a combination of qualitative and quantitative research techniques), the deployment included field observations and usability and accessibility tests. Each participant was taught individually by the researchers to use the device in one training session at the beginning of the study. Then InTouch was given to each participant to use as they saw fit. At least one family member had to be part of the study and participate in this training session to understand how InTouch works. These family members were encouraged to use their own devices to send messages to their participating seniors, but were not followed-up during the study to prevent bias related to 'topic involvement' (e.g., obligation to increase communication with loved ones due to the study).

The training sessions were staggered, so that only one participant was introduced to the study per week. These staggered starts were required by the long-term care facility, due to staff support and logistics (the facility only had one conference room and participants lived in shared rooms). The researchers followed-up with each participant weekly for approximately 20-25 minutes. Data from these weekly visits (informal conversations and observations) were written as field notes both in situ (if possible) and retrospectively.

The usability and accessibility tests were conducted four weeks after the training session, and were audio and video recorded. The participants, if interested, were able to keep InTouch at the end of the study. Our university Office of Research Ethics approved this study.

Participants

Staff of the long-term care facility, i.e., geriatric professionals, recruited our five participants. We asked staff members to distribute recruitment materials, namely a flyer about the study, a brochure about our lab, and a study description document, during meal times and social activities. Staff members then approached both interested and potential participants according to age and cognitive criteria. The selection criteria excluded residents with advanced levels of dementia, who would not be able to understand informed consent. Staff has access to residents' health records (for ethical reasons not shared with us), so they made the final selection. Recruitment among this population of oldest old is particularly challenging due to health and ethical issues. For instance, we were working with one long-term care facility and one independent living community and expected to have 8 participants in each institution. Some of the challenges we faced included health decline (cognitive and functional) and death within the initial pool of participants, which considerably affected the sample size. This sample size suits, nonetheless, our research strategy of an in-depth study of oldest old. Of these five participants (see Table 1), only four were able to fully participate in the study. Due to health problems, Ms.

Pseudonym	*Age*	*Gender*	*Previous occupation*	*Marital Status*	*Impairments*
Ms. A.	90	F.	-	Widowed	Stroke survivor; Wheelchair user
Ms. B.	81	F.	Factory worker	Widowed	Parkinson's disease
Mr. C.	88	M.	Businessman	Married	Stroke survivor; Wheelchair user; Use of one hand
Mr. D.	84	M.	Teacher	Widowed	Stroke survivor; Reduced hearing; Wheelchair user; Use of one hand
Ms. E.	93	F.	Farmer and factory worker	Widowed	N/A

Table 1. Socio-demographics of the participants

A., is still in an early stage of introduction to the device (even though she was the first to be enrolled in the study).

Because we wanted to test our icon-based appliance in a cross-cultural context, the participants of our study were Chinese Canadian and spoke primarily Chinese: four spoke Cantonese and one spoke Mandarin. In the opinion of the researchers, they had a basic functional level of English. However, one of the researchers was fluent in Cantonese and the conversational data was mainly collected in the participants' native language with staff support. The age of the participants ranged from 81 to 93 (M = 87.2, SD = 4.8). Three were women and two were men. Additional socio-demographic information can be found in Table 1.

Data Procedures & Analysis

A Chinese-speaking researcher conducted the fieldwork accompanied by a Chinese-speaking staff member at the long-term care facility and by an English-speaking researcher. The Chinese-speaking researcher and staff member translated the conversations in situ for the English-speaking researcher, who took notes. Before the coding process, the data was translated to English by the Chinese-speaking researcher and complemented by the field notes of the non-Chinese speaking researcher. We made provisions to independently validate translations by using a second Chinese-speaking researcher, when necessary.

The data were analyzed with individual profiling and thematic analysis: first, we crafted profiles of each participant, which "allows us to present the participant in context, to clarify his or her intentions, and to convey a sense of process and time, all central components of qualitative analysis" [33]. Second, we examined categories, patterns, and connections, trying to find a balance between within-case and cross-case analysis [31]. The thematic analysis mostly involved an inductive approach, i.e., themes emerged from and were grounded in the data. However, due to its centrality in the literature on technology adoption and older adults, TAM's indicators were also considered as a priori themes in the coding process (deductively). Yet, the inductive work provides an in-depth coding that overcomes the limitations of a deductive approach based on a single model such as TAM.

We used the following procedures: Firstly, the main, second, and fifth author coded independently to identify categories and themes. Secondly, the first and second authors coded together, using a label-coding scheme, and tested for convergence. Thirdly, the coded categories were conceptualized into broader themes. Finally, the fifth author examined the data to determine coding reliability: the inter-rater reliability for coding was 95%, calculated by counting discrepancies in category assignment between the codes and themes of the three authors, and by dividing them by the total category assignments.

RESULTS AND DISCUSSION

Critical Factors for Adoption

In this section, we consider factors that facilitated and hindered the adoption of a communication technology among our group of institutionalized oldest old. Of the five participants, only four fully adopted and used the device. Frequency of use varies across the four participants: on average, Ms. B. uses it four days per week, Mr. C. uses it twice every two weeks, Mr. D. uses it three days per week, and Ms. E. uses it three days per week.

From our field observations and usability and accessibility tests, we uncovered a set of factors, which included social, attitudinal, digital literacy, physical, and usability. These factors are not meant to be mutually exclusive categories; most are interconnected.

Social Factors

Social support, i.e., having family members deeply engaged in the adoption and use of our appliance, was a determinant factor for two of our participants. Even though Ms. B. and Ms. E. were digitally illiterate, the support provided by their family members enabled them to become functional users. The family of Ms. B. (daughter and granddaughter) would visit her often and would help her learn to use it; the daughter of Ms. E. would visit her daily and they would use it together. Within the four weeks between the start of the study and the testing phase, Ms. B. became the most frequent user of our participants. She also had the most social ties in her app contacts, which allowed her to communicate with a large social network and gain experience with the tool. Ms. E. did not use the appliance by herself frequently, but she seemed confident about the options that she used the most.

By contrast, Mr. C. only had one family member, his son, involved with the project. His son was not very engaged, did not visit often, and was his only app contact. In the four weeks of the study, there was very little communication between Mr. C. and his son on the appliance. During the usability and accessibility test, Mr. C. was unable to recall how to use the device and had to be prompted to perform tasks such as sending a picture message.

Besides reduced social support, other social factors that may act as demotivators for the adoption of a communication technology are related to contexts and cultural issues. With regards to contexts, adoption and usage may be reduced if participants are living in a setting that for security reasons requires devices to be locked and attached to their beds as in our study. As such, we recommend that designers

> **Factor security into the design of the interaction**, e.g., use of device while secured by a cable lock. (Recommendation *D1*)

Cultural idiosyncrasies can also affect the adoption of a device: for example, one of the icons (the wave) was not

perceived by the participants as a greeting sign but as a cancel sign, because this gesture means 'no' in Chinese culture. In our previous research with participants whose first language was English, the wave was considered the most basic function and, therefore, frequently used as the preferred option for novice users [3]. However, as our Chinese Canadian participants did not understand the cultural meaning of the wave, it was seldom used. For this, we suggest that designers

> **Consider (and evaluate early) cultural issues in the design of icons, particularly given users' age and strong attachment to a specific culture**. (*D2*)

Attitudinal Factors

The attitudinal factors entailed perceived usefulness, positive attitudes towards learning, and sense of ownership. Perceived usefulness is a category drawn from TAM, being primarily defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" [12]. Although expressed in an organizational context, this category refers broadly to the ability of a system to be used advantageously. In our case, perceived usefulness included users seeing value in our appliance for communication with family members. It also included the ability to choose different message types, for instance, three of the participants, Ms. B., Mr. C., and Mr. D., preferred to send audio messages to their family members and to receive text messages. According to these participants the audio option was more convenient, which seems to tap into their familiarity with the telephone as a communication medium. As Mr. D. puts it:

"They can listen to my voice and it's more personal, there is more communication in it".

The preference for the reception of text messages shows the importance of text or "paper-based" communication [18].

Usefulness was also connected to the fact that our technology allowed for different types of use: active vs. passive. Some participants reported preferring a more passive usage, including Ms. E. and Ms. B., which meant receiving messages instead of sending out messages (lurking), whereas others preferred a more active approach, such as Mr. D. For example, Mrs. E. was very assertive about her preference for using the device to receive messages, particularly pictures, as she was illiterate. As such, we encourage designers to:

> **Design a communication system that allows for different types of use (passive vs. active) and different types of messages (audio, text, etc.) that suit the large diversity of uses and users**. (*D3*)

Other aspects that confirm the perceived value of our appliance were 1) the message history, and 2) its advantage over existing communication technologies, especially when communicating with family members living abroad. For instance, Mr. D. explains:

"The telephone is hard to hear, so this is better because I receive a text message in Chinese and can reply with an audio message...Email is hard because the keyboard of computers are in English...With this I can send audio messages in Chinese and my son can respond with text in Chinese."

We found that four participants, with the exception of Ms. A., were active learners, displaying positive attitudes towards learning. During the researchers' weekly visits as well as participants' family visits, participants would ask questions about how to use the device. Ms. B. and Ms. E.'s family were especially instrumental in the learning process, reminding them how to do things on the appliance when they forgot. Mr. D. reported referring to the paper-based manual when using the device. All participants expressed the need to practice to become proficient users, indicating their desire to master InTouch. In Mr. D.'s words:

"I don't say it's very easy [to learn the tool], because then you won't have a good attitude to learn more about it"

Ms. B., Mr. C., and Mr. D. had a sense of ownership or property of the tool, which seemed to facilitate its adoption. For example, Mr. D. changed the language settings of the tablet to Chinese. He also frequently used the tablet to browse Chinese news sites. Both Mr. D. and Ms. B. had a clear sense of preferences for message types.

To address learning challenges, we suggest that researchers

> **Provide a variety of assists (e.g., frequent face-to-face training, a printed user manual) because this population appreciates additional support**. (*D4*)

Digital Literacy

Mr. D. had experience with a desktop computer, so he was also very comfortable with the idea of using InTouch. He understood the purpose of our appliance because he uses email to communicate with family. In fact, he was familiar enough with technology to be able to brainstorm some additional features for our appliance, such as a voice-to-text and translation feature. He suggested that this would enhance inter-generational communication for this cultural group since younger family members mainly speak English.

The other four participants (Ms. A., Ms. B., Mr. C., and Ms. E.) were digitally illiterate, which means that compared to Mr. D. they showed an overall lack of understanding of tablets and applications; in other words, they did not know much about what could and could not be done with the device. However, the strong social support of two of our participants, Ms. B. and Ms. E. compensated for their lack of digital literacy. These observations reinforce the recommendation we made in [3] to:

Design a communication technology more as an appliance and less as a computing device. (*D5*)

Physical Factors

All of our participants were frail, which at times hindered their use of the device. Motor and dexterity issues were the main demotivators, as Ms. B. puts it:

"My hand does not listen to me! Sometimes my hand does not listen to me…"

Mr. D also adds:

"I have fat fingers…"

All participants complained about the heaviness of the tablet (10"), and reported that it made it difficult to use some of the app features such as the camera and video camera. Although we provided a tablet cover that converted to a stand, this was not sufficient to use the tablet comfortably. Even though participants viewed the weight of the tablet as a significant barrier to its use, they found ways to overcome it including resting the tablet in their arm and having other people help them lift the device. As such, we suggest that designers

Address physical factors, such as the weight of the device and dexterity issues of this population, and account for limitations in the mobility of the appliance, e.g. users may not be able to use the appliance while walking. (*D6*)

Usability Factors

We found that perceived ease of use was a major facilitator of adoption. Perceived ease of use is a category drawn from TAM that refers to the "degree to which a person believes that using a particular system would be free of effort" [12]. But we observed that even though many of our participants had difficulty completing some tasks, they reported that the task was not difficult per se. Therefore, we had to separate this category into conceptual ease of use and practical ease of use.

1. Conceptual Ease of Use

Often users were not able to remember the steps to complete a goal, such as sending a video message to a contact. However, once the researchers reminded the participant how to complete the task, the participant would rate the task as not difficult. The researchers observed that once the participant got the hang of using the device in the usability test, they became noticeably comfortable with the device. Another interesting finding was that two of our participants (Mr. C. and Mr. D.) mentioned repeatedly that if they had more practice, they would know how to better use InTouch. They also felt that it was easy to use, but they were not completely familiar with it after the four weeks of having the device. This suggests that at a conceptual level, they perceived it as not difficult to use even though it was not easy for them to perform some tasks at that moment.

2. Practical Ease of Use

Our participants reported that some functions were easy to execute and we could see them comfortably executing them. For instance, Ms. B., Mr. C., and Ms. E., remembered how to access the message history and scroll through and view old messages. They rated these tasks as easy to complete, and they were very relaxed with these features during the usability tests. The same happened to Ms. B., Mr. D., and Ms. E. in terms of getting to and swiping through their contacts.

Our data also shows that they were able to infer, guess, and recall how to perform certain functions easily. For example, Mr. C. was able to send a video message during the usability test even though he had struggled before with sending a picture message. These examples demonstrate the level of learnability of our appliance.

3. Ambiguous Affordances

One of the aspects worth reporting about this particular group of older users was their literal understanding of the icons and functionality. For example, when asked to send a wave message, Mr. D. wanted to record a video message of himself waving. Ms. B. thought that the camera icon indicated the ability to send both picture and video messages. Mr. C. and Mr. D. interpreted the arrow icons as a description of the required gesture. The icon for switching front and back cameras was a circular arrow, and the icon for going back was a curvilinear arrow icon – we observed both participants tracing the icons with their fingers when interacting with them.

None of the participants were familiar with touchscreen gestures, so they did not know when to use swiping vs. tapping. It seemed that they would choose one over the other at random whenever appropriate feedback from the appliance was not provided. Although we did not ask for their preference of swiping over tapping, we noticed that swiping seemed to give them a sense of control. In fact, Mr. C. explains:

"Sometimes when I poke at it doesn't go anywhere, but swiping gives a response."

Because ambiguous affordances can hinder adoption and create frustration among users, we recommend to

Avoid the use of ambiguous affordances, and test/redesign the interface early on with the target users to detect any unexpected meanings attached to the interface elements. (*D7*)

And, given this population's lack of understanding for gestures and non-familiarity with conventions surrounding mobile interface affordances, we suggest that:

Explicit affordances are provided and the icons indicate how to gesture (e.g. arrows for swiping)**, even if this means sacrificing aesthetics**. (*D8*)

Recursive Approach to Technology Adoption

Our data shows that even though most models of technology adoption consider different factors [19], the adoption of a communication technology by the oldest old is the result of a complex interaction of social, individual (physical and attitudinal), and usability factors. Some of these factors were encountered in prior research with older adults [22, 24, 29, 41], and even in other user groups, for instance, in low-literacy adults [27]. However, the specific context of institutionalized frail oldest old demonstrates that these factors cannot be evaluated individually. Our findings indicate that some factors seem to compensate for others, e.g., strong social support compensated for digital illiteracy.

In this sense, TAM is limited as a theoretical model since it neglects the interplay of social context, human agency (individual choices), and inherent properties of technology. As such, a recursive approach is more adequate to frame the critical factors for technology adoption found in this study. A recursive approach assumes that contexts and technologies are not distinct dimensions but mutually related, so researchers should study "technologies-in-use" and the relationship between structure (social context) and human agency over time [17]. Our in-depth study over a two-month period allowed us to explore those relationships. Within this recursive approach, Strong Structuration Theory (SST) offers a quadripartite framework to study those relationships that includes: 1) external structures (conditions/dispositions of action), 2) internal structures (knowledge of external structures), 3) active agency (actions/practices), and 4) outcomes [34]. Adapted to the study of technology [17], SST helps to illustrate that our social, attitudinal, physical, and usability factors are intertwined in a dynamic network of structural (e.g., living settings, social support, literacy), agentic (e.g., attitudinal), and technological (e.g., InTouch's characteristics) dimensions. In other words, all these factors interact to provide a particular context of adoption of a novel technology among the oldest old. Context is not only the cause but also the outcome.

Therefore, researchers interested in this population should:

> **Account not only for technological and non-technological factors but also for the interplay between them during technology adoption and evaluation**. (*E1*)

Technology Evaluation with the Oldest Old: Challenges and Suggested Solutions

During our study of oldest old and their adoption of a novel technology, we encountered several challenges concerning not only the selection and implementation of evaluation methods but also the recruitment and training of participants. Some of these methodological issues were mentioned in a few studies with older adults [13, 24, 37, 40, 41], but not yet addressed in a systematic or sufficient way. This section answers RQ3 by describing our challenges and advancing possible solutions, which aims to improve the research on adoption of technology by this population.

Recruitment of Participants

The recruitment of institutionalized oldest old poses a significant challenge for research, due to their different levels of frailty, ability to consent to the process, and low digital literacy. A crucial part of the recruitment process was getting meaningful buy-in from the staff. In a previous attempt to conduct the study in a different setting we found that the lack of engagement by the staff was a major impediment to recruitment and ultimately to the study. By contrast, the staff member at the location of our study was extremely engaged in the process. But the lack of involvement of other staff members put pressure on scheduling sessions with participants. In addition, we did not have direct contact with participants' family members outside of the facility, having to rely solely on staff to communicate with them. This added to scheduling issues and lack of follow-ups. Another challenge was that the cognitive decline of one of the participants was not promptly reported to us, which limited the participation and interaction with her and raised ethical concerns.

To address the above challenges, we suggest that researchers:

> **Ensure proxies (staff, caregivers) are engaged since the inception of the study, in its design, recruitment, and evaluation**. (*E2*)

This would ensure an ongoing relationship between staff and researchers, facilitating access to important information about family interactions and possible changes in participants' health (which could affect consent and participation). If staff is engaged, they will be more willing to give access to the participants' family members. Staff engagement could be accomplished by info sessions tailored to staff members, where the project, researchers, and goals are presented and discussed in an informal and interactive meeting. To increase the trust of the staff and to alleviate their burden, researchers should also be involved in the recruitment of participants. For example, researchers can organize open info sessions for residents and family members, since existing literature on recruitment of older adults shows the importance of face-to-face activities [2].

Introduction to the Technology

Our deployment included an initial training session with the participants. In these training sessions we encountered five main challenges: first, we did not account for the level of security of the institution before starting the study, which meant that the tablet had to be secured by the staff before the participant was able to start using it alone. Additionally, adding a security lock to the tablet after the training session introduced an unfamiliar element to the appliance. Second, we prepared an interactive scenario between the two researchers conducting the training session to demonstrate

the use of the technology and put it into context, but during the training sessions we had to change our approach because the participants were eager to interact with the appliance. Third, another challenge we encountered was the lack of digital literacy of one of our participant's family members. During the training sessions, family members were supposed to interact with participants using their own devices (computers or smartphones) as a part of the demo. Even though one of the participants' family members had an android phone, she did not know how to send or receive emails. Therefore, the demo with the participant was not interactive since one of the researchers had to teach the family member to use email on her smartphone. Fourth, although we introduced touch screen gestures (tapping and swiping) during the training session, we did not teach them outside of the context of the appliance. In our usability and accessibility tests, we observed that the participants were still not comfortable with touchscreen gestures. This observation highlights the need to teach gestures in isolation from the outset. Fifth, we observed that due to the frailty of the participants and the deviation from their established routine, 50-70 minutes sessions were overwhelming and did not allow them to fully absorb the information.

We put forward some suggestions to overcome the limitations described above. First, ask staff if participants will be able to keep their devices with them in a secure place. If not, add a locking system before the introduction. This would prevent the addition of a possibly negative element to the device. To address the second, third, fourth, and fifth challenges, we suggest that researchers

> **Conduct training sessions that are frequent, flexible, brief, and inclusive of family members**. (*E3*)

In particular, we recommend a **less structured approach** to the training session allowing for customization. Researchers should guide participants through the demo facilitating their interaction with the device. If participants' family members are not sufficiently tech-savvy to be able to communicate with the participant through their own device, arrange a training session **with the family member prior to the introduction session** to teach them. Finally, training sessions should be **shorter** (40 minutes or less) and **more frequent** to accommodate for the participants' pace and mental endurance – especially since practice and repetition are crucial to enhancing learning and usage [7, 30]. This is supported by recent research that shows that fluid intelligence, which declines with age and affects working memory, can be improved by training [19]. And all participants indicated the need to practice more as to improve their digital literacy.

Usability and Accessibility testing

Our study followed a user-based testing approach to improve upon the interface and user experience. The usability and accessibility tests included an ordered task list and a set of questions and scales [21]. Although we applied the standard procedures for usability and accessibility testing, we found that some aspects were difficult to follow due to the characteristics of our sample. Firstly, the **Think Aloud technique** [38] **did not work** with our participants since they were too frail to perform tasks and explain them at the same time. Secondly, they **could not quantify their answers in terms of the 5-point Likert scales** that we used to measure their perception of the difficulty of the task or in some cases the appearance of the interface. For instance, Ms. B. reported that some tasks were:

"Sometimes easy, sometimes hard…"

In most other cases, quantifying the difficulty of a task seemed to be too abstract for them to rate. Thirdly, self-presentation and impression management [16] (the need to make a good impression on the researcher) were obvious during the testing sessions: two participants (that only had the use of one hand, Mr. C. and Mr. D.) reported that the device was easy to lift, but when asked to perform it they acknowledged that it was actually not that easy. In another example, all participants expressed that they did not find anything wrong or difficult with our appliance but then we saw them struggling with some tasks. The feeling of being tested or evaluated, even though we set it up as an informal activity, could have contributed to their impression management efforts.

Because of these problems, we encountered two limitations with the usability and accessibility testing: we could not fully understand their strategies and perceptions or grasp their mental model of the system. For example, we did not know if they recalled the steps to perform a task, if they were able to infer them or if they were simply using trial and error. Furthermore, as the participants were unfamiliar with touchscreen gestures, they had no notion of gesture conventions (i.e., swipe to scroll). Therefore, we did not understand why at some times they would choose to swipe over tap and vice versa. With regards to their mental model of the system, we did not know if they understood that the interface was consistent across icons and actions on different screens. Sometimes it seemed like they had a notion that they could perform the same sequence of steps in a different context, but other times it seemed that they were pressing the most salient icons at the time.

To address some of these issues, we advise researchers to

> **Ensure the evaluation techniques are appropriate to the ability and level of literacy of the participants.** (*E4*)

In order to take the burden off the participants and possibly reduce impression management efforts (the perceived need of participants to make a good impression on the researcher), we recommend:

Asking about how other older adults they know or that live in the same residence would perceive or assess that communication technology. (*E5*).

Finally, we suggest that researchers

Aim to shed light on users' mental model of the system and their strategies to perform tasks (*E6*)

While evaluating InTouch in situ with oldest old users, several approaches emerged for implementing the above recommendation (*E6*). For example, researchers may ask participants to **explain the meaning of icons and features**. This can provide insight into their level of understanding of what they know they can do with a communication technology. Additionally, by having participants use a mock-up designed specifically for testing purposes that has same icons and similar steps might help to test for inference and their understanding of consistency across different screens. To explore their strategy for accomplishing a task, ask if they guessed or remembered how to do it **from their previous experience** with the original communication technology. This can also reduce anxiety and impression management, since they will not be expected to know how to do everything in the new context.

Another way to shed light on their mental model of the system is to **ask users to explain to a friend** what the communication technology does. This will reveal their overall understanding of the tool, and whether they are missing some important concepts. Users' perceptions towards the use of the tool can be revealed by **asking comparative questions**, such as their preference for swiping vs. tapping. Having the participant **perform the task before answering** the researcher's question will likely produce a more accurate response (i.e., lifting the device before reporting how difficult it is to lift it). Finally, we found it useful to **remind participants** how to do the next step in the sequence to get them back on track, as they often could not remember how to achieve the overall tasks even though they were able to recall some of the steps.

CONCLUSION

This article explored factors that facilitate and hinder adoption of a novel communication technology by institutionalized oldest old (80+). Our findings show that a complex interplay of factors – social, attitudinal, physical, digital literacy, and usability – influence the adoption of communication technologies. Researchers and designers should not consider these factors in isolation, but as inter-related: for example, strong social support compensated, in some cases, for the lack of digital literacy. Despite the fact that this age group is often considered homogeneous because of their overall frailty, we also found that even within our sample there was significant diversity between individuals. In addition, our study reveals a set of challenges in the technology evaluation process. These challenges relate to recruitment, training, and usability and accessibility testing. Based on our experiences, we suggest a set of possible solutions to overcome some of these challenges.

Since we aimed to gain an in-depth understanding of a group of institutionalized oldest old, this research is limited by a small and non-representative sample and by possible cultural idiosyncrasies of Chinese Canadians. Yet, our work adds to the existing but scant literature on the field and contributes further with a reflection on research and design difficulties and recommendations. Future research should compare technology adoption across different cultural groups, consider longitudinal studies of adoption and use, and also test and expand upon our proposed solutions. In light of the lessons learned, we are now designing a new deployment study in a multi-site strategy (including residents of long-term or complex care facilities and home-care recipients) to deepen our recursive approach to technology adoption and to test our evaluation solutions.

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