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Older adults' perceptions and preferences of a fall risk assessment system: Exploring stages of acceptance model

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Abstract

Aging in place is a preferred and cost effective living option for older adults. Research indicates that technology can assist with this goal. Information on consumer preferences will help in technology development to assist older adults to age in place. The study aim is to explore the perceptions and preferences of older adults and their family members about a fall risk assessment system.

Using a qualitative approach, this study examined the perceptions, attitudes, and preferences of 13 older adults and 5 family members about their experience living with the fall risk assessment system over five points in time. Themes emerged in relation to preferences and expectations about the technology and how it fits into daily routine. We were able to capture changes that occurred over time for older adult participants.

Results indicated that there is an acceptance of the technology as participants adapted to it. Two themes were present across the five points in time – safety and usefulness. Five stages of acceptance emerged from the data from pre-installation to two years post installation. Identified themes, stages of acceptance and design and development considerations are discussed.

Keywords

Technology acceptance; older adults fall risk; aging in place

Introduction

It is projected that there will be about 72.1 million older adults by 2030¹. The increase in life expectancy offers additional living choices for this older adult population. The overwhelming preference of this growing population is to remain at home or to age in place².

Aging-in-place is a cost effective approach for senior living, and with the assistance of home and community-based programs, it has the potential to reduce inappropriate or premature institutionalization of older adults^{3,4}. Many older adults wish to live in their homes for as long as they are able, even though health issues may create challenges to aging –in-place^{2,5}.

Technology has an important role within aging-in-place; it helps older persons to maintain their health and independence^{6,7,8}. The use of technology in the home offers an alternative to long-term care options such as assisted living^{3,4}. In addition, it has been demonstrated that technology can assist in meeting specific needs and requirements of seniors, improves health care cost-effectiveness and supports caregivers^{6,7,8}. Therefore, an examination of older adults' perception, attitudes, and preference toward technology and technology use is important in order to learn more about functional and psychosocial factors in technology acceptance and adoption.

Older adults' positive attitudes toward technology are most often related to how the technology helps daily activities and facilitates convenience. Perceived usefulness and ease of use are reported to be two salient factors that explain technology acceptance and utilization for older adults as articulated in the technology acceptance model⁶. Negative attitudes are related to inconveniences created by technologies. According to Peek and colleagues², some community dwelling seniors report various concerns when they consider using new technology for aging at home. High cost and consequences of using technology are the major concerns of older adults. Seniors worry about forgetting or losing the device, false alarms, burdening children, or obtrusiveness. Some seniors express concerns about negative effects on health from the technical devices, the fear of stigmatization, or no control over technology². Also, older adults raised concerns about the learning curve in adopting new technology and the perceived difficulty of learning⁹.

In other research, there were mixed opinions about technology use and privacy. In one study, over 72 percent of older participants expressed acceptance of an in home monitoring system and indicated a willingness to share the collected data with their families or physicians. However, around 60% of participants expressed some concern about potential privacy issues in using the monitoring technology.

Even with these reservations, participants expressed a high regard for the monitoring assistance¹⁰.

One major functional problem for older adults that impacts aging-in-place is instability and an increase in falls. Statistics reveal that on an annual basis, one in every three people 65 and older fall, and two million are treated in emergency departments for fall related injuries.

Frequent falls and fall related injuries have the potential to impact an individual's ability to age in place ¹¹.

In conclusion, the perceived benefits of in-home monitoring may exceed concerns about privacy issues. Learning more about the perspectives, attitudes, and preferences of older adults toward technology will assist in our understanding of factors that influence adoption and use, features crucial for well-designed technology, and the adjustment process in living with the technology. In particular, this study will add to our knowledge about older adults' perceptions of in-home sensor monitoring systems within independent living environments. It will also provide information about if and how these perceptions change over time.

Fall Risk Assessment Systems

In response to this issue, our team installed fall risk assessment sensor systems (FRAS) in the apartments of consented older adults. The FRAS consisted of pulse-Doppler radar, a Microsoft Kinect, and two web cameras as a part of a more complete sensor network for in-home use (See Figure 1). The radar and the Kinect systems are set up to detect motion within their fields of view. For fall detection specifically, the radar system produces radar signals (electronic wave forms) and employs signal processing techniques which detect sudden changes in motion and then filter out false alarms like sudden door closing or housekeeping activities. The Kinect system produces images in 3-dimensional space, uses machine learning approaches to detect falls, and has fewer errors since it can differentiate sudden motion between different directions (e.g., lateral motion vs. vertical motion). Two web cameras are used to produce traditional video images as well as anonymized images in 3-dimensional space¹².

The radar unit is installed in a decorative wooden box located next to the front door of the apartment. The Kinect is discreetly placed on a small shelf over the front door. Privacy of the resident is preserved through the use of a depth image which presents as a moving silhouette; this depth image and the radar data are captured on a continuous basis¹². Figure 2 provides an example of a fall captured by the FRAS.

Fall risk assessments were also completed using six clinically validated fall risk assessment tools:

Timed up and Go (TUG), Berg Balance Scale (BBS), Short Physical Performance Battery (SPPB), Functional Reach (FR), Single Leg Stance, and 10 foot walk time x2. The assessments were completed concurrently with sensor data collection so that the automated fall risk assessment using the sensors could be validated ¹². The assessments were facilitated and scored by the clinical research staff.

In addition to these quantitative data, consumer perception interviews were conducted independently of the fall risk assessment process. These interviews were recorded and analyzed using qualitative methods. All methods were reviewed and approved by the Institutional Review Board.

Qualitative Study Methods

One objective of this study was to explore the perceptions and preferences of older adults and their family members about the FRAS, so that we could address any concerns or problems that emerged as we were developing it. This was achieved through individual face to face interviews with the older adults living with the sensor system, and face to face or telephone interviews with the family members of those participants who had family members willing to participate in the study, and who the older adult gave us permission to contact. After study introductions and consenting, an initial set of interviews were conducted at the pre-installation phase of the project, using a structured interview guide. This interview guide was developed by experienced qualitative researchers and was based on a quality of life technologies approach which stipulate that understanding the needs and preferences of the end user, in this case, the older adult, is a first step in the technology development process. The technology acceptance model⁶ was also used to inform the development of the interview guide. The structured interview guide included open ended questions and prompts which encouraged the participant to expand on the answer. Questions covered content such as: Describe your experience living with the FRAS? How does the FRAS affect your daily living? Has the FRAS helped in anyway? Is the information you receive from the FRAS helpful? How might you change any part of the FRAS? These are examples of the kind of information that was collected in the interviews.

After this initial interview, the FRAS were installed in participants' apartments. Thirteen participants were actually interviewed during the course of the study. The participants range in age from 67 to 98, with five males and eight females. The average age is 86.86 (standard deviation 7.62). Five family members participated in the study and were interviewed once during the study at various times when they were available. The relationship of all of the five family members to the older adults was that of daughter.

Interviews were then conducted every other quarter with residents for four additional times as residents lived with the sensor system. Using the same structured interview guide that was used in pre-installation, interviews were completed by a member of the research staff. Interviews were from 15-20 minutes in duration. Interviews were tape recorded and field notes were taken at each of the interviews.

A content analysis was performed on the collected data. A predetermined coding scheme was not used to code the data since the content analysis was data driven and inductively generated from the collected data. Naturally occurring variations in the data were noted; patterns, codes and themes emerged from the data¹³. Analyses were performed by two members of the research team. The analyses were performed separately and then together. Consensus in interpretations was achieved through discussion.

Results

Family Responses

All family members interviewed were aware of the sensor system in their parent's apartment. Three daughters reported they were informed about the equipment at the point of

installation. One remarked that their parent showed them the new equipment. The installation and new sensor system placed in the apartment was perceived as something novel and interesting to talk about – at least initially.

While all of the family members interviewed knew about the sensor system, two mentioned that they knew what the FRAS did and one family member reported the periodic checking-in by staff as a benefit. One family member expressed pleasure about her father's involvement in the project, particularly the monitoring aspect. While family members expressed awareness about the system, two family members stated that they were uninvolved. Three family members articulated no personal benefit from the sensor system. However, there was anticipation of future benefits and two family members expressed hope in the utility of such a product.

Most of the daughters provided ideas for sensor system changes. Aesthetics emerged as important, particularly regarding the visibility of the radar box and Kinect. One daughter stated: "I notice the box whenever I try to rearrange and make the apartment look nice."

Family comments emphasized the need for the FRAS to address safety issues. One family member suggested: "Could the system prompt mom to use her walker?" Another family member suggested that the data collected be used to provide instruction to the family on how to make the home environment safer. Daily feedback reports and enhanced coordination with nursing and rehabilitation staff were other suggested features offered by family members. The development of feedback and assessment information for people who are struggling with memory decline was another idea offered by one daughter: "How can this information be presented in a way that is useful since she (mom) forgets so quickly?" One last suggestion for improvement was to expand the range where the equipment senses movement. One daughter noted that the bathroom contained areas not picked up by the sensors.

Overall, family reactions to the FRAS were positive. Only one family member identified privacy concerns, particularly about being watched. But as her mother lived with the system she went from being concerned about privacy to bragging about her mom having the equipment in the apartment. We see from this information that for family members there is an adjustment period. Initial concerns may alleviate, as the benefits of the FRAS are realized over time.

Resident Responses

Table 1 displays the themes that emerged or continued over the 5 data point times throughout the study.

Pre-Installation—Themes that emerged at the pre-installation phase in terms of expectations about the system were security, unobtrusiveness, aesthetics, usefulness, and privacy. When asked about how the system would help them, themes of security and usefulness surfaced. Specifically, residents felt more secure about their safety and that they would receive assistance quicker. One resident remarked: "It gives me assurance that if something were to happen, I would have help". Relief was expressed in knowing that health

care staff would be monitoring unsafe movements and one resident remarked: “It could be a lifesaver if I fall.” Unobtrusiveness, privacy, and aesthetics materialized as several residents commented that they did not anticipate that the sensors would interfere with their day to day routine and that the FRAS would blend into their apartment surroundings. For example, when the FRAS was explained to one resident, she remarked that she was pleased that her privacy would be protected and stated that it was not going to intrude on her home environment.

Residents also anticipated the usefulness of the FRAS. They articulated that their safety would be improved because falls would be recorded and staff would be monitoring these falls. There were several comments about how the system would help them examine their behavior so that they could prevent falls or correct their movement to prevent or avoid falls. One resident mentioned: “It will help me be more careful when I am walking around both inside of my apartment and outside of it.”

Finally, at pre-installation phase, residents were asked to identify what information would be helpful to them and what they would like the FRAS to display. The primary feature they wanted to see were individualized health alerts that contained their own personal health data. In particular, residents were interested in knowing how their health data was changing. They wanted the FRAS to track improvements and activity/movements that could improve their fall risk.

First Interview Post-Installation—As the residents began to live with the FRAS, they had an increased understanding about it which influenced their expectations. They remarked that they were settling in with it, and getting used to it. Emerging themes included positive regard, serving a purpose, and connection. Positive regard was identified in their expression about having the system in their apartments “feeling good about it” and “glad that it is here” are some of the articulated comments. In terms of serving a purpose, residents remarked that the study overall would help older adults in the future with fall risk detection and that their participation in the study had the potential to improve the quality of life of others. Connection was another emergent theme in this phase. Some residents discussed that they liked having “extra” contact with the researchers, study staff, and clinical staff associated with the project. Others felt a strong connection to their own health information which they believed might help them to monitor and improve their behavior.

Unobtrusiveness and aesthetics continued as themes in that residents articulated that the system was barely noticeable, the FRAS blended in with the living environment, and there was no interference with their daily routine. When residents were asked about how the system has helped them in their day to day living, the same themes of security, and usefulness identified in the pre-installation interviews surfaced in these post- installation interviews. They continued to feel assured that health professionals were watching for risks and that the alerts would summon help if one got into trouble. One resident articulated: “If I fell at night, someone would know. I really do feel safer because I fear falling.” In terms of usefulness, comments about the system being helpful due to increased awareness of actions and movements were articulated again. Some residents believed that the fall alert system helped them be more careful in the home environment. When asked if the information they

received from the FRAS was helpful, several residents pointed out that they liked the regular fall risk assessments and they used these assessments as a guide to help them improve their identified weak areas. Participants stated that it was interesting to see how they improved over time. Receiving feedback and reports continued to be a highlight for the residents. When asked about what information they would like to receive that they were not getting there were a few comments about learning techniques to help keep them safer.

Second Interview Post- Installation—At this phase, when asked to comment about their experience living with the system, and whether it interfered with their daily living, themes of complacency and motivation emerged. Complacency materialized since at this point, no respondent raised objections or articulated any negative comment about how the FRAS operated, and they were settling in with the system. Comment such as “The system is fine,” “It doesn’t bother me,” and “I don’t mind having it in my apartment,” were comments that spoke to this emerging complacency. When residents were asked about how the FRAS has helped them, themes of safety, usefulness, and connection continued to be articulated. Residents articulated that if they were to fall, they knew that someone would help them. One resident believed that the system encouraged more monitoring by the healthcare staff. In terms of connection, residents continued to remark that they enjoyed the contact with researchers and students. One emergent theme in this phase was motivation. Several residents articulated that the FRAS has helped them “try a little harder to be active.” One resident stated: “It inspires me to do more activities.” The aesthetics of the system was mentioned as something that could be improved; some residents did not like the color, location, or style of the wooden box that held the equipment.

Third Interview Post-Installation—At this point in the research project, there was some attrition of residents due to deaths and relocations for functional reasons. Of the remaining residents who continued in the project, they were adjusted to the FRAS and the theme normalized emerged. Residents stated that they “forget that the sensors are in the apartment”; “do not think about them nor notice them”. There was no interference with daily routine. One resident stated: “I don’t even know that it is there. It has become part of the scenery.” It is interesting to note that aesthetics was not an issue in this phase.

Security and usefulness continue as themes and residents mention that the system was helpful overall and they like the monitoring by health care staff. One resident stated: “I feel reassured that if there was a change in fall risk, someone, the care staff, would be aware.” The theme of motivation was present as residents continued to link their increased effort with the project. There was a sense of confidence that greater effort will result in improved activity as observed in this quote: “The fall risk assessments have made me more aware of my ability and inability to walk, stand, and balance in my environment. I make a greater effort, so I am able to do well each month.” Residents continued to make comments about how they enjoy the extra contact they have with students and researchers which continued the theme of connection. Finally, when asked what information the residents would like to see, in addition to wanting their own individual data and report, there was a request to add information about how the individual data differs from the norm.

Fourth Interview Post-Installation—At this final phase, the theme of normalized continued in relation to the resident's perceptions of living with the sensor system in their home environment. One resident remarked "I forget it's there." In terms of how the sensor system has helped the resident, safety as a primary benefit continued. One resident stated: "I have been involved a long time. I am happy to help. I have not fallen yet, but think it's neat that they (care staff) can be alerted if I were to fall." Residents also made comments about the usefulness of the FRAS in helping them remain in their home. The theme of connection continued and residents remarked again about how much they enjoy interacting with the researchers and staff and the benefit of seeing more people. No new themes emerged at this phase as data saturation was achieved. When asked what they would change about the system, there was a suggestion about expanding the sensors to monitor more areas in the apartment, such as the bathroom.

Stages of Acceptance

Resident reactions and perceptions were tracked over time, and the data were examined for both consistency and changes in perceptions. Researchers reviewed this data for patterns and themes; stages of acceptance regarding the use of gerontechnology emerged from this analysis. Table 2 provides information on each stage, the phase of the project in which these stages emerge, and a description of the stage.

Noted from the descriptions, as residents went from thinking about installation of the sensors to living with them over time on a regular basis, their expectations were influenced by the reality of living with the FRAS and adapting to it. Over time the FRAS became a normal part of the environment, no longer a novelty, and eventually accepted as a helpful device within one's living environment.

Discussion

This study demonstrated that sensor monitoring was regarded positively by the residents and family members who were interviewed. Sensor monitoring was viewed as a means to hold on to independence and allowed residents to age in place. The high regard for the sensor system remained intact over 5 points in time. Overall, for both groups, privacy issues did not emerge as a major concern. Instead, participants and their family members focused on the benefits of such a system in terms of usefulness, safety, and security. The lack of expressed concerns about privacy may be due to the fact that the sensor images, while tracking movement, do not reveal detailed features of an individual. Rather, the image displayed is that of a shape. For the one family member who had privacy concerns initially, the concerns were alleviated over time as her loved one lived with the system. These findings are congruent with other studies that reported, usefulness and need balances out privacy concerns for individuals^{14, 15, 16}, and these findings support the technology acceptance model⁶ Also, information collected by the FRAS is only shared with health care providers who are selected by the older adult, so in this study, older adults were involved in all decisions about who saw their data. Using this resident centered approach to sharing information may have also lessened concerns about privacy.

Also, in line with a resident centered approach, for this independent population of older adults, family members were not involved with the collection and monitoring of the sensor data. Most knew about the FRAS and could envision a future benefit of the system to assist in communication of their loved one's changing status. Most expressed support for their resident family member's involvement with the FRAS. However, they saw it mostly as the resident's project. When they were involved, they advocated for the FRAS to be aesthetically pleasing to the environment, or offered ideas for how the system could evolve to be helpful to caregivers and other family members. Family members.

Another phenomenon that occurred through the sensor monitoring is that residents felt compelled to move safer, to live healthier as a result of the connection they felt with the health care and research team. Perhaps the fact that participants knew people were paying attention to them served as an enhancer to do better. The connection to health care professionals appeared to be a positive value of having the monitoring system in place. They enjoyed interacting with the researchers and clinical staff. This enjoyment is something to be considered as further research and services of the future when sensors are commercialized for home use.

The findings of this study are significant in that it demonstrates that sensor technology may be a solution to assist people to age in place for longer periods of time and to avoid institutionalization. An implication for practice is that health can be monitored using this technology thus avoiding premature and costly institutionalization of older adults who have health conditions.

There are strengths and limitations to this study. The strengths are that the collected data contains a thorough examination about the perspectives and preferences of older adults in independent living environments and their family members. The research provides insight into how a small group of older adults with some functional limitations cope and adapt to the infusion of technology resources to help them age in place.

Additionally, since data were collected at five points in time, we were able to track expectations and the adjustment process over time. We were able to capture information related to whether the initial expectations about the technology system were met over time and whether other expectations emerged. We were also able to track the perceptions of the value and usefulness of the technology system for older adults over time and to depict which perceptions and values changed and which continued to be present through the course of the project. In the tracking of how perceptions and attitude change over time, stages of acceptance in the use of gerontechnology emerged from the data.

The small sample size and qualitative nature of the research limits generalization of results to other contexts. In addition to this limitation, the research focused on the use of a fall risk assessment system which is one specific type of gerontechnology in one independent living environment. It is not known whether the results will transfer to other settings, other population groups, and other types of gerontechnology. Our study participants were at a point in their lives where they were searching for ways to remain independent and this factor may have impacted their willingness to accept sensors and their perceptions over time.

Additional research is needed with a larger sample of older adults with varying levels of abilities in a variety of living environments to further test acceptance and perceptions of gerontechnology.

In conclusion, this study provided an opportunity to examine resident opinions and preferences about a developing FRAS over 5 points in time. In addition to resident opinions, family/caregiver opinions and preferences were collected about the sensors. For this sample population, The FRAS was regarded as a tool that helped increase their safety, activity level, and served as a motivator to do better. The results suggest that for this limited sample, interest and acceptance of the FRAS was motivated by a declining functional status and a desire to age in place. Future research should examine for the emergent and recurrent themes and stages of acceptance with gerontechnology that were discovered in this study.

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Figure 1.
Sensor Network

Figure 2.
Three sequential depth images from the Microsoft Kinect showing of a resident fall.

Table 1

Emergent Themes, Recurrent Themes, and Design Feature Suggestions Identified Across Five Points in Time

Phase	Time Frame	Emergent Themes	Recurrent Themes	Helpful Features Identified
Pre-installation	Before FRAS Installment	Security, Unobtrusiveness, Aesthetics Privacy, Usefulness		Individualized health alerts
Post – installation 1	6 months post installation	Positive regard, Serving a purpose, Connection,	Unobtrusiveness, Aesthetics, Usefulness, Security	Monthly feedback reports, Learning techniques for safety
Post-installation 2	1 year post installation	Complacency, Motivation	Unobtrusiveness, Security, Usefulness Connection, Aesthetics	Monitoring by healthcare staff
Post- installation 3	18 months post installation	Normalized	Security Usefulness Motivation, Connection	Individual data and how it differs from the norm
Post-installation 4	2 years post installation	No new themes emerge	Normalized, Security Usefulness Connection	Expansion of the sensors to monitor more areas

Table 2

Stages of Acceptance

Stage	Phase	Description
Anticipation	Pre-installation	Foresee life with the sensors. Expectations about benefits and burdens.
Transition	Post-installation	Transition from expectations to reality; settling in to reality
Adjustment	Post- installation	Adapting to the technology in the home environment.
Normalization	Post -installation	Technology becomes a standardized feature of the living environment
Acceptance	Post-installation	Technology is an accepted part of everyday living.