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Older adults' attitudes towards and perceptions of 'smart home' technologies: a pilot study

GEORGE DEMIRIS†*, MARILYN J. RANTZ‡,
MYRA A. AUD‡, KAREN D. MAREK‡, HARRY W. TYRER§,
MARJORIE SKUBIC§ and ALI A. HUSSAM§

†Department of Health Management and Informatics, School of Medicine, University of Missouri-Columbia, USA
‡Sinclair School of Nursing, University of Missouri-Columbia, USA
§Department of Electrical and Computer Engineering, University of Missouri-Columbia, USA

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Abstract. *Primary objective*: The study aim is to explore the perceptions and expectations of seniors in regard to 'smart home' technology installed and operated in their homes with the purpose of improving their quality of life and/or monitoring their health status.
Research design and methods: Three focus group sessions were conducted within this pilot study to assess older adults' perceptions of the technology and ways they believe technology can improve their daily lives. Themes discussed in these groups included participants' perceptions of the usefulness of devices and sensors in health-related issues such as preventing or detecting falls, assisting with visual or hearing impairments, improving mobility, reducing isolation, managing medications, and monitoring of physiological parameters. The audiotapes were transcribed and a content analysis was performed.
Results: A total of 15 older adults participated in three focus group sessions. Areas where advanced technologies would benefit older adult residents included emergency help, prevention and detection of falls, monitoring of physiological parameters, etc. Concerns were expressed about the user-friendliness of the devices, lack of human response and the need for training tailored to older learners.
Conclusions: All participants had an overall positive attitude towards devices and sensors that can be installed in their homes in order to enhance their lives.

Keywords: Smart homes; Telemedicine; Usability; Elder care

Introduction

The rapid growth of the elderly population and increase in life expectancy have led to new models of positive ageing where older adults are being empowered to lead fulfilling lives and adapt to degenerative changes to maintain functionality, autonomy and quality of life. Independence is a critical issue for many older adults as they age. However, in the pursuit of independence, often the older adult's safety and health are at risk as they try to cope with health-related issues such as falls, sensory impairment, immobility, isolation, and medication non-compliance. Specifically, falling is often the sentinel event that marks the beginning of functional decline [1]. Injuries result from one-third of falls. Falls are also the leading cause of death from trauma for older adults. Impaired vision and impaired hearing are

*Author for correspondence; University of Missouri, 324 Clark Hall, Columbia, Missouri 65211, USA; e-mail: DemirisG@health.missouri.edu

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also common problems for the older adult population. Although 80% of older adults have 'fair to adequate' vision, 36.8% have macular degeneration, a disorder that destroys central vision, and 2% are totally blind [2]. Fifty percent of older adults experience impaired hearing [2]. Approximately 30% of older adults, mostly women, live alone and are at risk of becoming socially isolated [3]. Approximately one-third of older adults have some condition limiting mobility [1]. Finally, older adults use between 40 and 60% of over-the-counter medications sold [2] and the risk of incorrect use and adverse reactions increases with the number of prescribed and over-the-counter medications.

The aim to meet older adults' desire to remain independent at home while controlling home health care costs has led to the development of 'smart home' technologies. A smart home is a residence equipped with technology that enhances safety of patients at home and monitors their health conditions. Therefore, the devices and sensors chosen to be installed and maintained in the older adults' residences need to address functional limitations and social and health care needs.

Several pilot projects have introduced 'smart home' technologies both in the US and Europe. One such pilot project, the SmartBo project in Sweden [4], was created in a two-room ground floor demonstration apartment operated by the Swedish Handicap Institute. The project utilizes solutions for elderly with mobility impairments and/or cognitive disabilities (such as dementia and developmental disability). Devices and sensors control lighting, windows, doors, locks, water outlets, electrical power and stoves, as well as visual and tactile signalling devices, speech synthesizers, and Braille displays for the visually impaired. A similar project for older adults was introduced in the Netherlands [5] using devices for control of lighting, sensors for optimal processing of temperature and heating, and remote control of several other functions. The project PROSAFE [6] identified abnormal behaviour of a monitored patient that can be interpreted as an accident, and collecting representative data on a patient's nocturnal and daily activity. The design of the Smart House in Tokushima, Japan [7] placed emphasis on eliminating barriers within the residence, and maintaining secured lifelines in case of a natural disaster. Finally, in the US, the Georgia Tech Aware Home Project [8] features two identical independent living spaces to allow for controlled experiments with technology and to enable inhabitants to live on one floor while demonstrating prototypes of assistive technologies on the other floor.

While these initiatives demonstrate new dimensions of current technology, they also point out the need for an assessment of the needs and expectations of older adults. If we fail to take the needs of older adults into consideration and instead design systems driven only by the features of current technology, we are 'at risk of adopting approaches that are too closely associated with medical, and disempowering, models of older age' [9]. There are only a few studies that investigate older individuals' perceptions of smart home technologies or other home-based technological applications. One of these studies that address this concept is by Vincent *et al*. [10] who examined the application of environmental control systems in the homes of users and caregivers and concluded that the use of remote control by people with moderate cognitive impairments was difficult, while verbal reminders were greatly appreciated. A further study by Demiris *et al*. [11] investigated older individuals' perceptions of videophone and monitoring technology that can be installed in their homes and found that the respondents had an overall positive atti-

tude towards the use of home-based technology. Our study focuses specifically on 'smart home technologies.'

The theory of diffusion of innovations also motivates this study. This theory suggests that the diffusion of an innovation depends to a great extent on the circumstances under which it is being introduced, the people exposed to the innovation and their perception of its usefulness [12]. The diffusion of innovations begins with early adopters who are willing to explore new possibilities and risk trial use, and to lay the groundwork for others to follow. Thus, assessment and understanding of seniors' perceptions of smart home technologies are essential in planning and predicting the future use of such technologies.

Many have discussed what the features of a smart home should be [13–15]. There appears to be a consensus in terms of the main functions of a smart home; i.e., it should enhance the independence and improve the quality of life of residents. Thus, when compared to traditional housing arrangements, smart homes bring added value to the consumer, i.e., the elderly resident.

This study is an initiative placed within the framework of Aging in Place, a new model of long-term care for older adults [16]. This model allows older adults to age in the least restrictive environment of their choice. Key to Aging in Place is the separation of *type* of care and *place* of care. In this model, clients direct the timing and intensity of health and personal care services delivered to them in their home, and thus, have the opportunity to 'age in place.' Forcing a frail older person to move from one setting to another as needs change results in mental and physical deterioration [17–19].

The Aging in Place project includes Tiger Place, a 34 000 square foot facility in Columbia, Missouri, developed by the University of Missouri-Columbia with Americare Systems, Inc., of Sikeston, Missouri. Construction of Phase 1 of Tiger Place with 32 apartments began on 6 acres of land in spring 2003 and is scheduled to open in spring 2004; phases 2 and 3 are planned for additional units. Within Tiger Place, emphasis has been placed on a state of the art building and apartment design that supports independence, therefore helping residents to age at home and not in a nursing facility [20].

The aim of this pilot study was to assess the perceptions and expectations of seniors in regard to technology installed and operated in their homes with the purpose of improving their quality of life and/or monitoring their health status. Furthermore, this study sought to uncover the reactions of senior citizens to devices and sensors that can be installed in their homes, and to explore their opinions of possible usefulness or concerns. This study was also part of a needs assessment that will prepare for the design of a system of devices and sensors that will address the needs and concerns of older adults as identified in the findings of this preliminary work.

Methods

We conducted a series of focus group sessions to assess older adults' perceptions and expectations of the technology as well as ways they believe technology can improve their daily lives. The sessions were facilitated by members of the research team and followed facilitation guidelines for focus groups by Krueger [21]. At the beginning of the focus group session, the facilitator introduced the purpose of the study. The focus group protocol was approved by the Health

Sciences Institutional Review Board of the University of Missouri-Columbia. The sessions were audio taped for later analysis by team members.

An invitation to participate in the focus groups was posted at several locations within a Continuing Care Retirement Community in Columbia, Missouri. Continuing Care Retirement Facilities (CCRF) are senior residences that offer several different kinds of care including private independent living units, an assisted living facility, and a skilled nursing facility. All the types of care are offered on the same grounds, allowing residents to receive a variety of services as their needs change. We scheduled three sessions within this facility so that residents interested to participate could attend one of them. The primary author (GD) was the focus group facilitator.

The focus group protocol included questions about participants' current experience with technology, and their perceptions of the usefulness of devices and sensors in health-related issues such as preventing or detecting falls, assisting with visual or hearing impairments, improving mobility, reducing isolation, managing medications, and monitoring of physiological parameters. These health-related issues were selected after a review of the nursing literature revealed them as issues of concern for older adults and health care providers alike.

In addition, the focus group protocol included questions about other areas of daily living where assistance is currently needed or may be needed in the future, and about possible concerns associated with the use of the technology such as violation of privacy and confidentiality, usability issues, and training. In order to ensure the protocol's validity, the questions were reviewed by a team consisting of researchers experienced in instrument development and health care providers. The audiotapes were transcribed and a content analysis using the software package QSR N6 (QSR International Pty Ltd., Australia) was performed. For each theme of the focus group protocol, a label, a definition of the theme, indicators on how to flag the theme, description of qualifications or exclusions and examples were defined when using the software package. This allowed for the definition of categories that emerged from the transcripts.

Results

A total of 15 older adults over the age of 65 participated in three focus group sessions (six in the first, five in the second and four in the third session). As mentioned earlier, these participants were volunteers who responded to an invitation posted within the continuing care retirement facility and attended one of three scheduled sessions. Each session lasted approximately 1 h. Seven participants were male and eight were female. Table 1 depicts demographic information of participants and their current experience with computers. Fourteen participants used

Table 1. Information about focus group participants

	Total	Male	Female
Number of participants	15	7	8
Users of a personal computer (PC) at home	14 (97%)	7	7
Users of email program and web browsing	10 (66%)	6	4
Users of advanced software applications (e.g., image processing software, financial organizer)	4 (26%)	2	2

personal computers (PCs) at home. Ten of those used a PC to send and receive emails and to browse the web, while the remaining four also used advanced software applications (e.g., image processing software or a financial organizer).

The content analysis revealed the following predominant categories where smart home technologies would benefit older adult residents:

- emergency help
- assistance with hearing and visual impairment
- prevention and detection of falls
- temperature monitoring
- automatic lighting
- monitoring of physiological parameters (e.g., blood pressure, glucose levels)
- stove and oven safety control
- property security
- intruder alarm
- reminder system announcing upcoming appointments or events
- timely and accurate information on adverse drug events and contraindications.

The participants voiced five concerns related to the use of technological devices:

- possible privacy violation resulting from the use of cameras
- lack of human responders or a possible replacement of human assistance by technology
- the user-friendliness of the devices, and
- the need for training tailored to older learners.

These concerns were raised during all three sessions. The order they are listed does not reflect the perceived importance. During the discussion, all these concerns were perceived as equally important to the participants.

All participants felt that the use of cameras within their homes for the purpose of identifying falls or other accidents was 'obtrusive' and would be violating the resident's privacy. When asked if the use of such cameras were to be 'anonymized' where shadows or movements would be depicted but one could not identify the features of the individuals, many participants felt that this solution was more appropriate. A participant raised a question about the extent to which one should be utilizing advanced technology to postpone or delay a deterioration of the physical status of elderly, that a participant described as '[something that] will happen anyway whether we like it or not.' An additional concern expressed was that the success of such technologies requires human assistance to be available and respond to the data or alarms generated by the technology. As one participant stated, the presence of 'even the most advanced technology is useless, if there is nobody at the other end . . . to react to the information [that the system provides].'

The majority of participants spoke about the level of user-friendliness of new devices. The majority of interfaces are not designed to take into consideration the functional limitations that come with age. As a result, some tasks requiring the use of technological devices become even more difficult for the older adult. Table 2 summarizes the functional limitations that were addressed by the participants during the focus group sessions. Furthermore, many participants felt that

Table 2. List of functional limitations as expressed by the focus group participants

Vision loss
Hearing impairment
Loss of tactile senses
Memory loss
Loss of balance
Difficulty reading fine print
Difficulty using small buttons
Difficulty processing information when displayed together with features perceived as distracting (e.g. watching news on TV with background music, browsing the web with pop-up windows)
Difficulty using computer mouse

there is a need for training sessions and manuals that are designed specifically for senior citizens who may not be familiar with the operation of certain devices or the technical language used. A participant emphasized the fact that some people are 'technophobes' and refuse to utilize new technologies. For such residents, the argument was made that a non-obtrusive device, one that functions as a sensor and does not need to be operated or controlled by a user, would be more appropriate.

Five participants reported experiences of friends and family members who had utilized alarm devices that can be used to notify a call centre in emergency situations. Problems described were the individual's refusal to wear such a device at all times, to use it in actual emergency cases and limitations in mobility as some of these devices would function only within a certain area. One of the participants stated that his friend had decided to use such a device to have 'peace of mind.'

Three categories were identified in relation to the installation of the technology: (a) wearable technology where a device is worn, carried by or implanted within the user or attached to prostheses (e.g., cane, wheelchair); (b) local installation of devices and sensors fixed within the residence and (c) a remote operation with networks operating in a larger community. Participants did not object to any of these types of installation and would accept any such device if it were to improve their life or prevent accidents. However, three participants stated that they could think of friends or relatives who would refuse to 'wear' a device, being afraid that it would stigmatize them as frail or needing special assistance.

All participants had an overall positive attitude towards devices and sensors that can be installed in their homes, and in general, towards the concept of 'smart homes' as they expressed their interest in new technologies and their belief that there can be numerous ways of improving their everyday lives. They also expressed willingness to try out new technologies if those were readily available. Two participants raised the issue of cost expressing the concern that they might not be able to pay for the installation of smart home technologies. In summary, participants emphasized that devices and sensors installed in their homes can be of great benefit when they are reliable, user friendly, can detect a range of emergencies, require no or minimal action on the part of the user, have low maintenance costs and are not obtrusive.

Discussion

A review of the 'smart home' demonstration projects reveals the lack of an extensive evaluation of their impact on seniors' quality of life. These projects have focused on developing an experimental unit; thus, the intervention has been tested only with selected individuals. In addition, these projects have focused only on the

use of technology in 'experimental' rooms or environments aiming to achieve technological advancements, but are lacking a model that addresses an aging in place clinical approach that would ensure sustainability and acceptance by older adults.

In this study, we take advantage of the fact that our senior population has relatively uniform living conditions. This removes variables that are difficult, if not impossible to control, and thus, the results are, for the most part, generalizable to an independent home living condition.

It is noteworthy that the seniors in our study independently confirmed that most of the risk factors we identified were indeed causes of serious concern to them. The risk of falling due to sensory impairments and decreased mobility was a common thread. These seniors seemed to have an active socialization network as expressed by the high percentage that used email and the world wide web. Assistance with medication administration was not mentioned as a personal concern by any of the participants. In addition, there was no mention of the problem of incontinence, which is described in literature as a major burden for older adults; perhaps this was due to the sensitivity of the issue, given the openness of the meeting, rather than an absence of need.

The notion that senior citizens are inclined to reject new technologies has also been countered by Collins *et al*. [22] who, in reporting on a survey of 2500 older people, stated the lack of any evidence in this study 'for a positive relationship between age and technophobia.' Our study confirms this finding since all participants had a positive attitude towards technology and were willing to accept the installation of sensors and devices in their homes. However, it is noted that the sample for this study was recruited from a population of retired well-educated older adults from the upper middle-class income bracket. The high levels of computer usage and access, especially, are not applicable to all senior citizens. Therefore, the findings may not be generalizable to other groups of older adults. This limitation is to be expected as continuing care retirement communities, while suitable for recruitment of senior residents, are usually targeting the upper-middle income class of retired seniors.

Finally, one barrier to the development of smart homes relates to 'the absence of ethical frameworks to underpin them [9].' With technological advancements comes the desire to use such technology in all aspects of life; even in cases where such an implementation follows no framework or promotes outdated medical models that view users as dependent patients instead of enhancing their engagement, social inclusion and independence. The challenge as we create new technologies, is to understand the personal effects of the technology in order to make it better serve our human purposes [23]. This study provides insight into the expectations and perceptions of seniors and, in spite of its limited sample size, can inform system designers and care providers. In order for system designers and developers of new technologies to achieve a user-driven design that will increase usability and acceptance, these professionals need to consult with older people and assess their needs and expectations.

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