Dementia caregivers and technology acceptance: Interest outstrips awareness

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A.A. Burstein, O. DaDalt, B. Kramer, L.A. D'Ambrosio, J.F. Coughlin. Dementia caregivers and technology acceptance: Interest outstrips awareness. Gerontechnology 2015;14(1):45-56; doi:10.4017/gt.2015.14.1.005.00 **Issue** The demographic aging boom has drastically increased the prevalence of Alzheimer's disease (AD) or dementia in the United States, which in turn means a greater demand for family caregivers. The disease's toll weighs heavily on caregivers and their loved ones, and the strains continue to grow as the disease progresses. New technologies include tools that may ease the care burden or address other unmet needs. Despite the potential for these technologies, however, they are not widely used. Many previous studies examining technology use among caregivers have focused primarily on one factor - acceptance - as a dichotomous variable. **Method** This research addresses a more complex reality and explores caregivers' awareness of existing technologies and perceptions of emerging technologies to understand acceptance, drawing on 34 in-depth interviews with caregivers. **Results & Discussion** The results indicate that caregiver awareness of many newer existing technologies was relatively low, but that they did have interest in using emerging technologies to support with care. Interest in these newer technologies was strongly correlated with caregivers' perceptions of the usefulness of these technologies. The results point to the need for better communication to caregivers about the technologies that exist to assist with care and, in particular, how these technologies may be beneficial. This may be especially critical because some technologies are more likely to be useful to caregivers at different stages of the disease. Early information and education about available technologies may be essential in helping caregivers to plan and prepare to adopt new technologies as they need them.

Keywords: technology, dementia, caregivers, Alzheimer's, acceptance

In the United States alone, there are currently a reported 5.2 million cases of Alzheimer's disease (AD), the most prevalent type of dementia. Over the past ten years, rates of major causes of death in the United States including heart disease, HIV, and stroke have all been on the decline; only AD rates continue to rise[1]. Although AD was at one time considered to be a condition that simply happened to some people as they grew older, the disease is not a normal part of the aging process[2]. Nevertheless, the greatest risk factor for the disease is age, with the overwhelming majority of cases affecting those aged 65 and older[1]. Longer life expectancies and the aging of the baby boomer generation in particular mean a surge in the disease over the coming years. Currently, one in nine people in the USA over the age of 65 has AD, and the number of diagnosed cases is expected to more than triple by 2050[1].

The demographic boom in the older adult population not only means more people with dementia but also more family caregivers. In 2014 alone, family caregivers in the USA provided approximately 18 billion hours of unpaid care for their loved ones[1]. Family caregivers are typically the spouses, adult children or close relatives of a loved one with dementia; a majority of family caregivers are female[1]. Caregiver responsibilities may include direct care, such as dressing, bathing and feeding, organizational duties such as scheduling medical appointments and coordinating financial planning, and arranging or providing transportation. In addition to these tasks, primary caregivers may have to negotiate care in conjunction with other family members who may be divided about the care plan or care responsibilities[1]. Previous research on dementia has found that caregiving has physical, physiological, social and financial impacts on the caregiver[3]. Such impacts can include poor health, an increased likelihood of developing dementia themselves, a higher mortality rate, stress, depression, social withdrawal, and economic

hardship[1,3]. Unlike those with other fatal conditions, individuals with dementia can suffer with the progressive disease for over a decade[1]. As a result, caregivers may be faced with a continuous sense of loss as their loved one gradually declines; losing both cognitive and functional abilities until eventually they are unable to perform even simple daily tasks. In addition to the burdens of direct care, the costs of care and challenge of ensuring funds lasting throughout the course of the disease can be overwhelming[4].

Fengler and Goodrich[5] cautioned the gerontological community that spousal caregivers of elderly and disabled individuals were 'hidden patients'. While the individual with dementia is the focus of care, the strain of the disease on their spouses, children, friends and other relatives who are providing care often goes unaddressed. Research on caregiving around dementia has made significant strides toward a better understanding of the condition of caregivers and their needs. In addition to psychosocial studies on caregiver and dementia patient well-being, research has also been done on the potential of various technologies to improve the quality of life for caregivers and their loved ones. Technology has been touted as one solution to address the unmet needs of caregivers and their loved ones and to reduce the burden of care on family caregivers. A literature review by Lauriks et al.[6] identified four categories of needs specific to caregivers and their loved ones with dementia: the need for general and personalized information; the need for support with regard to symptoms of dementia; the need for social contact and company; and the need for health monitoring and perceived safety.

While many dementia technology studies trying to meet these needs have been conducted with participants living in residential care facilities[7], there is an increasing demand and need for designers and engineers to consider the home environment or the context of use when developing new technologies[8]. Individuals prefer to age in their own homes[9], and family caregivers often try to keep their loved ones at home as long as possible; according to the Alzheimer's Association, keeping a loved one at home is one of the top three reasons caregivers decide to provide care[1]. Caregivers may want to keep them in the home out of deference to their loved one's wishes, their own preferences and/or cost - even as the disease progresses and care recipients' needs may overwhelm the caregiver. Recent research and the development of new technologies reflect this trend, as the focus has shifted away from residential care to care in the home setting. For example, a recent study by Kerssens carried out personalized technology interventions in the home to manage neuropsychiatric symptoms of dementia[10].

There is an active body of literature concerning technology for dementia care and support. Topo[7] and Bharucha et al.[11] offer extensive literature reviews of this research. Topo's review spans dementia technology studies from January of 1992 through February 2007. Topo found that while research typically focused on a single dementia related issue, studies that investigated technology for communication and social inclusion were limited. Recruiting participants living at home within the community was frequently a challenge among studies[7]. Caregivers and their loved ones are a population likely to be low on time and energy, which makes them an elusive sample. Researchers often include those with AD as well as participants with various forms of dementia or cognitive impairment in their studies, which could translate to potential benefits for other populations with similar day to day challenges, such as those with developmental disabilities. A complementary review of literature on technologies and commercially available products for dementia care from Bharucha et al.[11] spans 1965 until 2009. This review identified and explored various technologies used for dementia care, such as monitoring systems for wandering issues, smart home technology for safety, memory aids, and tools for socialization. Bharucha et al. conclude that more research, which considers the needs of older adults by utilizing the concept of user-centered design, will bolster the development of relevant and context specific technologies in dementia care.

Past studies are difficult to compare due to differences in technology types, discipline and study scope. A review of extant literature, however, suggests past studies have been primarily focused on use and less on acceptance of technologies. Most studies were intervention-based, meaning that they asked caregivers to use the technology, without first seeking their opinions on why or how they thought it would be useful. Some studies, such as Rasquin et al.[12] and Olsson et al.[13], did seek to gain participants' opinions on the technologies they were testing, although they limited their inquiries to certain types of technologies, anti-wandering systems and information and communication technology (ICT) devices, respectively. This tendency to focus on one technology or one technology application such as ICT, memory aids, or tools for physical safety, is typical of the assistive technology research done in the past. More recently, researchers such as Mehrabian et al.[14] focused on the acceptance of technology among patients with AD or mild cognitive impairment (MCI) by

describing a tele-monitoring system, a technology which addresses several limitations of the disease. There is also more current research focused on older adults and technology adoption in general such as work by Cjaza[15], which explores health monitoring technology as part of a larger assessment of available technologies.

The dissemination of near-market technology is the ultimate goal of the research such as the work by Wu et al.[16] who gauged the perception of an assistive robot among a population with MCI. Yet the focus on one type of technology limits the generalizability and scope of the work. Learning about what motivates technology acceptance and adoption and canvassing opinions across technology types are going to be critical to the acceptance of relevant near market technology that is user centered for caregivers and their loved ones.

Numerous technology studies have shown that acceptance and adoption of technology can sometimes be difficult among older adults and their caregivers[8,17-19]. Yet, in order for caregivers to reap the benefits offered by different technologies, it is essential that researchers understand the factors that will influence caregivers first to accept, and then to learn to use them. Certain variables have been shown to be positively associated with the acceptance of technology among older adults, including the value or benefit of the technology that users perceive and perceived ease of use[8]. In short, older adults and their caregivers are much more likely to be interested in and to accept and then adopt a new technology - assuming that they are aware of its existence - if they can envision specific ways it would help them and if they believe it would be relatively easy to use[8,20-23]. According to Davis's Technology Acceptance Model (TAM)[20], these two factors, perceived usefulness and perceived ease of use, lead to the individual's attitude towards using the product (positive or negative), which in turn affects intention to use, which finally leads to actual use. The model also posits that perceived usefulness of the technology can directly affect behavioral intention to use (*Figure 1*). Thus, rather than simply assess caregivers' use of different technologies, more research efforts need to be directed toward the left side of *Figure 1* in collecting information from caregivers on their awareness and the factors that lead to the acceptance, and ultimately adoption, of a range of technologies.

In this study, we aimed to gauge caregivers' awareness of existing technologies that could aid with care and their acceptance of new technologies drawing on in-depth interviews with 34 caregivers of loved ones with dementia. In particular, we were interested in whether caregivers were aware of different assistive technologies currently on the market, and whether their awareness levels differed based on the nature of the technologies. We also wanted to explore caregivers' interest in using or potentially adopting new technologies that have the potential to aid in or support dementia care, and what factors were more likely to support acceptance opinions at present and in the future around the technologies. A portion of this study replicates interviews originally done in Germany[24] on dementia caregivers' interest in new technologies. The results of this study can be used to inform future technology development and lead to broader acceptance and use, with the hope of easing the burden on caregivers and their loved ones.

Methods

Sample

The sample consisted of 34 individuals who provided care for a loved one with a diagnosis of dementia and nearly all of them (94%) were the patients' primary caregivers. Six male caregivers and 28 female caregivers took part in the interviews, all between the ages of 43 to 76 with a median age of 61. Caregivers' incomes ranged from US$25,000 or less to over US$150,000, with a median income bracket of US$50,000-US$74,999. Most of the caregivers in the sample were spouses (14; 41%), although there were also a number of adult children and grandchildren (12; 32%). Three of the participants were friends or neighbors (8%), and the remainders were other relatives, such as siblings, nieces, nephews, daughters-in-law, or cousins (5; 15%). Care recipients included 19 females and 15 males, ranging from 55 to 94 years old, with a median age of 78. A majority of these were in the 'moderate' stage of dementia (21; 62%), 6 (18%) were in the 'mild' stage, and 7 were in the 'severe' stage (21%), as determined by the authors utilizing caregivers' reports to items from a clinical scale from the LEANDER study which followed the ICD-10 criteria[25]. All care recipients lived in the community,

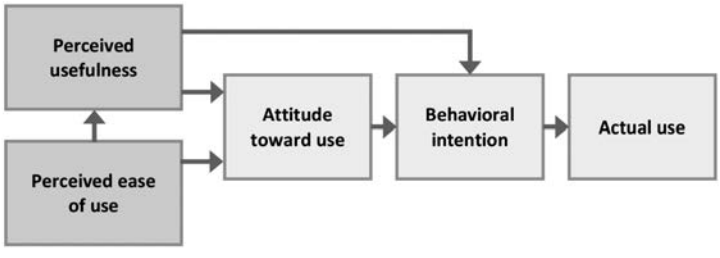


Figure 1. Davis's Technology Acceptance Model (TAM)[20]

Table 1. Characteristics van caregiver interviewees and their care recipients (CR)

Parameter		Female	Male	Whole sample
CAREGIVER				
Gender, n		28	6	34
Age, years		60.3±7.7	54.7±10.0	59.3±8.3
Primary caregiver		28	4	32
Relationship to CR	Spouse	13	1	14
	Child	9	1	10
	Other family / friends	6	4	10
Education level	High school / some college	14	2	16
	College / some graduate school	14	4	18
CARE RECIPIENT				
Gender, n		19	15	34
Age, years		82.7±8.0	71.1±8.9	77.3±10.1
Dementia stage	Mild	4	2	6
	Moderate	11	10	21
	Severe	4	3	7
Living status	Alone	7	1	8
	With others	12	14	26

with others (26 CR) or independently (8 CR), not in a nursing home or other type of professional care facility (*Table 1*).

Data collection

The convenience sample was recruited by a professional focus group facility. To be eligible for the study participants had to live in or around the metro-Boston, Massachusetts, area, and be providing care for a loved one with a diagnosis of dementia who lived in the community, not in a home or other sort of residential care facility. Subjects were compensated US$125 for taking part in the in-person interview; interview length ranged from one to 2.5 hours, with the average interview lasting 107 minutes. A portion of the interview replicated items from a German study on dementia caregivers' technology acceptance[24]. The interview included closed and open-ended questions about the caregiver's background, the loved ones for whom they were providing care, and their caregiving duties. Interviews were conducted in participants' homes (14; 41%), at the university (17; 50%), or at other locations participants deemed convenient (3; 9%). With respondents' permission, interviews were audio recorded and transcribed for analysis. The study and consent form were approved by the university's institutional review board.

To assess awareness of caregiving technologies currently on the market, the interview schedule included questions asking caregivers about their knowledge of assistive technologies (AT). Participants were provided with short descriptions of 17 AT and asked whether they: (i) already used the technology in their loved one's care; (ii) knew of the technology and knew where to purchase it; (iii) knew of the technology but did not know where to purchase it; or (iv) had never heard of it. The list of AT included both 'basic' AT, which were simple devices meant to help older adults with daily tasks such as walkers, and 'new' AT, which were recent to the market and either used sensor technology such as a fall detector, or were specifically directed at older adults with dementia like a GPS tracking device.

To explore reactions to new, emerging technologies, participants were shown laminated cards for five caregiving technologies. Each card contained a detailed description of the technology and an accompanying picture. The five emerging technologies targeted in the study were a GPS tracking system, Paro (a robotic therapy seal), an internet platform to provide caregivers with support, a social contact system for care recipients that operates through a television, and a health monitoring system (*Table 2*). These five technologies were chosen because they support different domains of caregiving as laid out by Lauriks et al.[6]: (i) safety and protection (GPS system), (ii) symptoms of dementia (Paro), (iii) information procurement (Information Platform), (iv) social participation (Social Contact System), and (v) health monitoring (Health Monitoring System). The technologies may also vary in their usefulness based on the disease stage of the care recipient. For each of the five technologies, participants were asked a series of eight questions about their willingness to use the technology (2 questions), the perceived usefulness of each technology (three questions) and their perceptions about how easy it would be to use (three questions). *Table 3* contains the wording for each of the eight items.

Analysis

All interviews were audio recorded and then sent for transcription. The two researchers who conducted the interviews reviewed and cleaned each transcript. The transcripts were reviewed for participants' specific comments and reac-

tions to each of the five emerging technologies. Closed-ended questionnaire data that participants generated were recorded on paper by researchers and then were entered into SPSS for analysis. The analysis included running a series of frequency counts, crosstabulations, descriptive statistics and correlations for variables capturing participant characteristics and measures of technology awareness, acceptance and use.

Results

Awareness and use

Participants reported most commonly being aware of more basic AT, and this high level of awareness was reflected in their high use levels (*Table 4*). Use of smoke alarms was universal, and nearly 80% of participants reported using grab bars, both 'basic' AT. This result is not surprising, considering that smoke alarms are standard or in some cases legally required in modern homes, and grab bars are relatively easy to install and recommended by many aging-in-place remodeling checklists[26]. Following these AT, participants were most likely to report being aware of wheelchairs, home emergency systems (like Life Alert), and walkers, although participants' use of these three technologies did not match their awareness, perhaps because of a lack of perceived or

Table 2. Description of five new technologies presented to caregivers

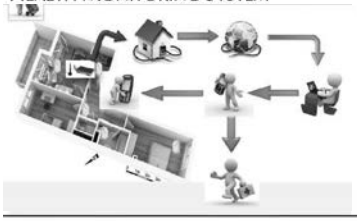
Technology	Description
GPS Tracking System 	-Consists of a watch equipped with GPS, safety lock, and mobile receiver for the caregiver -The watch is a transmitter that shows the location of the person with dementia
Paro 	-Animal therapy robot -Responsive to physical contact -Able to recognize voices, move its head in that direction and open and close its eyes -Provides comfort and reduces stress -Does not require care like a real pet
Internet Platform 	-Non-commercial links explaining various topics related to Alzheimer's and dementia -Forum where caregivers can connect and provide support for each other
Social Contacts System 	-An average TV at home equipped with an accessory device -Video calling -A platform to exchange photos, videos and messages with family and friends -An intelligent calendar with a reminder function that can be linked to family and friends and personalized headlines
Health Monitoring System 	-Home monitoring system -Records deviation from the norm, triggers alarm -Includes activity and temperature sensors -Fall recognition sensors -Water and humidity sensors in the bathroom (to detect flooding), smoke alarm and heat sensors at the stove -Intelligent medication dispenser -Vital sign monitoring.

Table 3. Interview items used in analysis; All items were scored on a 1 to 5 scale, with 1=strongly disagree; 2=somewhat disagree; 3=neither agree nor disagree; 4=somewhat agree; and 5=strongly agree; The perceived usefulness and perceived ease of use scales were participants' averaged scores across the three items within each scale

Parameter	Item
Participants' willingness to use	-Assuming I have access to this technology today, I would use it.
Participants' willingness to use in the future	-I could imagine using this technology in the future.
Perceived usefulness scale	-Using this technology would help improve care for my loved one.
	-Using this technology would be a relief for my daily care routine.
	-Altogether I think this technology would be useful in my daily care routine.
Perceived ease of use scale	-Interacting with the technology would not require a lot of mental effort.
	-I think I would have the technology under control.
	-Altogether I think the technology would be easy to use.

actual need for the technologies. Again, these AT are in the mainstream: wheelchairs and walkers are widely used and readily available, and home emergency buttons are frequently advertised on television. Among responses to the basic AT items, only one participant had not heard of a raised toilet seat, but over a quarter of the sample had never heard of a bathtub lift, and about one-fifth of participants admitted that they did not know where to buy one.

Participants were less aware of sensor driven AT and of AT that might specifically support dementia care. Lighting with sensors, front door monitoring, water sensor, stove safety, and GPS tracking were the new ATs that caregivers were most likely to report using or being aware of. Caregivers were more likely to report using or being aware of front door monitoring and of GPS tracking among the dementia related AT. A majority of caregivers, however, was unaware of any of the other sensor technologies, as well as of electronic calendars and medication dispensers. Over 70% also reported being unaware of a relatively widely accessible technology - stove safety devices. The specific AT of which participants were least aware were sensor mats, position sensors, water sensors, and electronic calendars for people with dementia.

Nevertheless, participants' overall lack of awareness of many of these AT, particularly many of the sensor and dementia-related technologies that have applications to facilitate aging-in-place, suggests that this market may be ripe for more information and education. Even younger caregivers were no more aware of or used these technologies; age had no bearing on awareness or use of the basic AT, the sensor AT, or the AT that might specifically support caregiving for someone with dementia. Upon diagnosis caregivers may learn a great deal about the disease and what they need to do to provide care, but they may not be made particularly aware of newer

Table 4. Caregivers' awareness of assistive technologies (AT); n=34; Total may not sum to 100 due to rounding

Technology	Answer %			
	Already in use	Heard of, know where to buy	Heard of, don't know where to buy	Never heard of
NEW AT - SENSORS				
Sensor mat	0	6	18	76
Fall detector	0	15	18	68
Position sensor	0	6	9	85
Lighting with sensors	24	41	18	18
Water sensor	6	0	9	85
NEW AT – DEMENTIA RELATED				
Stove safety	3	9	18	71
Front door monitoring	12	27	27	35
GPS tracking	3	30	32	35
Electronic medication dispenser	0	18	15	68
Electronic calendar	0	6	6	88
BASIC AT				
Bathtub lift	3	50	21	27
Wheel chair	24	77	0	0
Life alert home system	27	65	9	0
Grab bars	79	18	3	0
Raised toilet seat	56	41	0	3
Walker	47	53	0	0
Smoke alarm	100	0	0	0

technologies, or existing ones they have not had a previous need for, that might help to support care and therefore have the potential to reduce the burden of care.

Acceptance of emerging technologies

Willingness to use

We were also interested in understanding in greater detail caregivers' willingness to use emerging technologies. To that end, participants were presented in more detail than the previous 17 technologies with photos and descriptions of five new technologies (*Table 2*). We defined participants as being 'willing to use a new technology' only if they responded, 'strongly agree' to the following current use statement: "Assuming I had access to this technology today, I would use it".

Exactly half of participants (17; 50%) strongly agreed that they would use the Internet Platform, whereas slightly fewer said they would be likely to use the GPS Tracking System or the Health Monitoring System (for each technology, 15; 44%). Still fewer said they would be willing to use the Social Contacts System (10; 29%), and the smallest percentage of participants (8; 24%) said they would be willing to use Paro. This suggests that among study participants, the Internet Platform was the technology that would be most likely to appeal to them, perhaps because it seemed like it might be easy to use, especially considering that all participants had access to both a computer and Internet in their home. Of the sample, 82% reported that they had used or did use the Internet to search for information on dementia and care. Thus, adoption of the Internet Platform would not be particularly complicated or demanding for people. This is consistent with the claim that people are more likely to accept new technologies if they feel like they have high self-efficacy with the technology already, as well as the notion that the actual use of new technology can often be predicted by previous patterns of technology use, especially ICT[27,28].

We also asked participants about their willingness to use the technologies in the future. This question was used to gauge whether caregivers' preparedness to accept the technology was related to the current state of their loved one's dementia and its likely future progression, since most technologies are only useful in a certain stage of the disease. As with current use, we defined participants as being willing to use the specified technology in the future if they responded 'strongly agree' to the question "I could imagine using this technology in the future". The ranking of future willingness to use the technologies remained essentially the same as in current use, with the greatest number of participants saying they would be likely to use the Internet Platform in the future (21; 62%), followed by the GPS Tracking System (19; 56%), and the Health Monitoring System (18; 53%). Paro and the Social Contacts system each had the fewest number of participants who expressed a willingness to use them in the future (8; 24%).

For both current and future use mean scores, the order of technologies was essentially the same (*Table 5*), with the highest current and future use mean score assigned to the Internet Platform ($M_{current}$=4.15, SD=1.13 and M_{future}=4.47, SD=0.896), followed by the Home Monitoring System, GPS, the Social Contacts System, and Paro. For all technologies except the Social Contacts System, participants' mean scores for future use were significantly higher than for current use, underscoring that they were more open to using the devices in the future. This may mean that participants were not opposed to using particular technologies in principle, but may have simply failed to see any immediate use for them. Possibly they had no 'felt need'[29,30] for the devices at that time or could not see how they would fit into their current lifestyle or care situation but would be potentially interested in using them later on. The Social Contacts System may be an exception because as care recipients progress through the disease, they may be less able or interested in recognizing and conversing with loved ones, or caregivers may have felt that existing technologies such as Skype or FaceTime already meet this need.

Finally, we asked participants which of the five was their favorite technology overall, and which one they thought they would be the most likely to use now or in the future. The Health Monitoring System proved the most popular, with 15 of the participants (44%) naming it as their favorite, followed by the GPS Tracking System (10; 29%), the Internet Platform (5; 15%), Paro (3; 9%), and finally the Social Contacts System (1; 3%). These results suggest that although a greater number of people may report that they are willing to use the Internet Platform, the Health Monitoring System is the one that participants were most interested in using overall.

When asked why they liked the Health Monitoring System, participants' responses suggested that it was because additional monitoring would greatly increase safety for their loved one and reduce their worry as caregivers - in short, it was the one they generally thought would be the most beneficial. A female caregiver, age 59, commented that the Health Monitoring System was "like an invisible babysitter". Other caregivers mentioned that it seemed inclusive and

incorporated many options. Some even said it seemed to encompass the benefits of the other emerging technologies. One female participant, age 56, summarized the benefits of the system as: "It's everything that I do right now, you know. It would make me feel so much better about leaving my mom in her own home. It seems safe. And it encompasses everything in one thing". This may suggest that the 'health monitoring' domain is especially important to caregivers of people with dementia.

Conversely, when asked which technology was their least favorite, the greatest number of participants mentioned Paro (11; 34%), followed by the Social Contact System (7; 22%), the Home Monitoring System (6; 19%), the GPS Tracking System (5; 16%) and the Internet Platform (3; 9%) When asked why they disliked Paro, some participants commented that they found it somewhat 'fake' and 'regressive'. One female participant, age 65, said that her loved one might see Paro *"as an insult…. I don't know. I just think it's phony"*.

Predicting willingness

Davis's Technology Acceptance Model[15] posits that the perceived usefulness and perceived ease of use of a technology correlate with people's

Table 5. Measurements on caregivers' current and future use, perceived usefulness and ease of use of five emerging technologies; Table entries are mean scores based on a 1 to 5 point scale, where higher scores indicate greater likelihood of use; n=34; Difference between current and future use tested with 3 degrees of freedom in the Kendall's tau test; in bold-italic: p<0.01; in bold only: 0.01<p<0.05

Measurement		Emerging technologies				
		GPS tracking system	**Paro**	**Internet platform**	**Social contacts system**	**Home monitoring system**
CURRENT USE (CU) AND FUTURE USE (FU)						
CU		3.6±1.6	2.6±1.7	4.2±1.1	3.1±1.7	3.9±1.4
FU		4.2±1.3	3.4±1.4	4.5±1.0	3.1±1.6	.2±1.2
CU-FU		-0.62±1.3	-0.79±1.3	-0.32±0.64	0.00±0.73	-0.24±0.47
t		***-2.716***	***-3.506***	***-2.956***	0.000	***-2.766***
p		0.010	0.001	0.006	1.000	0.009
PERCEIVED USEFULNESS (PU) AND PERCEIVED EASE OF USE (PEU)						
PU		3.97	3.05	4.01	3.21	4.19
PEU		4.19	4.58	4.30	4.32	3.99
Pearson correlation	Use & PU	***0.659***	***0.736***	***0.813***	***0.897***	***0.910***
	Use & PEU	***0.562***	-0.023	0.267	0.087	0.524
WILLINGNESS TO USE BY GENDER, %						
Use now	Men, n=6	50	17	33	17	0
	Women, n=28	43	25	54	32	54
Future use	Men, n=6	33	17	50	17	17
	Women, n=28	61	25	64	25	61
WILLINGNESS TO USE BY DEMENTIA STAGE OF CARE RECIPIENT, %						
Use now	Mild, n=6	50	0	67	33	33
	Moderate, n=21	48	29	52	29	38
	Severe, n=7	29	29	29	29	71
	Kendall's tau-c	-0.083	0.138	-0.231	**-0.265**	0.096
Future use	Mild, n=6	67	0	83	33	67
	Moderate, n=21	57	29	67	24	43
	Severe, n=7	43	29	29	14	71
	Kendall's tau-c	-0.101	**0.317**	**-0.267**	**-0.262**	-0.016
WILLINGNESS TO USE BY CAREGIVERS' EDUCATION LEVEL						
Use now	High school / Some college, n=16	44	31	44	13	44
	College / Advanced degree, n=18	44	17	56	44	44
	Kendall's tau-c	-0.066	-0.291	0.111	**0.522**	0.042
Future use	High school / Some college, n=16	63	31	56	6	50
	College / Advanced degree, n=18	50	17	67	39	56
	Kendall's tau-c	-0.069	-0.294	0.097	**0.394**	0.042

willingness to use it, although the emphasis is placed on perceived usefulness as being a more direct predictor of adoption (*Figure 1*). For each technology, respondents answered a series of three questions relating to perceived usefulness and three questions relating to perceived ease of use for each technology (*Table 3*). Responses to each series of items were then averaged for each participant and then across all technologies: overall mean perceived usefulness and perceived ease of use scores (*Table 5*). The results show that people's overall rankings of usefulness of the technologies did not correlate perfectly with their ease of use scores. While Paro was identified as the easiest technology to use, it was also pegged as the least useful of the lot. Similarly, the Internet Platform ranked second in ease of use, but the Home Monitoring System edged it out in terms of usefulness.

The question, however, is to what extent these factors - perceived usefulness and perceived ease of use - weigh in people's willingness actually to use the technology. Among our small sample of caregivers, perceived usefulness was consistently and strongly correlated with technology acceptance across all technologies, whereas perceived ease of use was correlated with acceptance only for the GPS Tracking System and the Home Monitoring System (*Table 5*). This suggests that perceived usefulness of a technology was predictive of participants' responses about use of the technology. Thus it is important to participants that they can see how a technology would be able to support them in their daily care routines.

Ease of use was less strongly associated with acceptance, but it is not unimportant. When participants were asked about the factors they considered important in a new technology, all participants (100%) rated 'simple operation' (ease of use) as a very or somewhat important factor. This may in part be an artifact of the study design; because participants had only the technology descriptions but did not actually see or use the technologies, they were not readily able to assess ease of use. Regardless, while ease of use may be important to first acceptance and then adoption, the results here suggest that it alone is likely insufficient to convince consumers ultimately to adopt a technology. These results are consistent with Davis's model, which suggests that while both factors are important in determining acceptance, perceived usefulness will be more predictive of willingness to accept than will perceived ease of use[20].

Other factors

To explore whether any demographic factors were related to willingness to accept these new technologies, we looked at the results by a number of participant characteristics. First, although the study sample has a significant gender skew, female caregivers responded more favorably than males to current and future use of almost all of the technologies, with the sole exception of current use of the GPS Tracking System (*Table 5*). None of the six male caregivers in the sample agreed that they were very willing to try the Home Monitoring System. This general trend of female caregivers in our sample being more interested in a potential technology use than male caregivers might seem to run contrary to stereotypes about the adoption of new technologies generally[31,32]. The result here might simply be explained by the very small sample size, and the high female to male ratio of participants. Another possible explanation is that compared with men, women are more likely to be caregivers, to spend more time caregiving overall, and to perform more intensive caregiving tasks such as bathing and feeding[33]. Thus, women caregivers may be more interested in accepting and adopting technologies that would help them do these jobs or in any way reduce caregiving demands.

Age of caregiver was not related to willingness to use technologies currently or in the future. Contrary to any expectations that younger caregivers might be more interested in technology than older ones, a regression analysis of caregiver age on each of the willingness to use items revealed no significant relationships. We did find, however, that reported willingness to use the emerging technologies varied by caregivers' loved one's dementia stage. Caregivers' current willingness to use some technologies increased with the care recipient's disease progression (Paro and the Home Monitoring System), while willingness to use others decreased (GPS Tracking System, Internet Platform, and Social Contacts) (*Table 5*). This willingness to use likely tracks how valuable caregivers think each technology would be at different disease stages; it may be that once a person with dementia reaches a certain stage, caregivers feel some of these technologies would no longer be useful.

Disease stage of the care recipient also affected reported willingness to use the technologies in the future (*Table 5*); for example, participants with more severe dementia were more likely to agree to using Paro in the future, but less likely to agree to using the Internet Platform or the Social Contacts system. This may be because Paro is a technology specifically geared toward individuals with more advanced dementia and deals with the actual symptoms of dementia. In contrast, the Internet Platform and the Social Contacts System deal with procuring information about

dementia and encouraging social participation, both of which might be less crucial in a future where the disease has progressed and the patient needs more basic care.

We also examined the effects of the caregiver's education level on reported current and future willingness to use emerging technologies. Technology use differed little based on education level (*Table 5*). Only the Social Contact system showed any difference, with caregivers with higher levels of education more likely to report they would use it currently as well as in the future (*Table 5*). Perhaps this is because more educated caregivers were already familiar with features that the Social Contacts system provides, similar to Skype and photo sharing, and thus were more comfortable with the system.

Discussion

The results of this study suggest that dementia caregivers' knowledge of new technologies lags behind current technology development. Awareness may grow as the disease progresses, and as caregivers perhaps find greater needs and uses for additional help and support in providing care. Yet while caregivers were aware of many basic AT currently available in the market, newer sensor technologies or devices designed specifically to assist with dementia care were less well known among our sample. This lack of awareness translates directly to lower use; people unaware of a technology's existence cannot even engage in the question of whether to potentially use the technology or not. There is thus a need for more education, for caregivers to become better informed about existing technologies: what they are and how they might assist with caregiving. Only then can they consider adding a technology to support their caregiving efforts.

The presentation and discussion of five emerging technologies for dementia care focused more centrally on willingness to use rather than on awareness. The results suggest that caregivers' reported future willingness to use a technology generally outstripped their current willingness to use it. Willingness to use might not be the same as their overall favorite technology.

Willingness to use was closely related to caregivers' perceptions of usefulness of the technology and less strongly to ease of use. The findings also indicate that the dementia stage of the care recipient may affect willingness to use a given technology. There may be periods in the progression of the disease during which each technology is more likely to be useful to caregivers and their loved ones, and thus more likely to be used by them. Because most of these opportunity periods close before the patient reaches the severe stage of the disease, it is important for manufacturers to market their products early in order to alert caregivers to the options that exist to support them at different stages of the disease. The same is true for people who give advice to caregivers (family doctor, nursing service). These people need to be educated too to give advice on the potential of new technologies to support care in time. Indeed, as the results suggest, caregivers who may not be interested in using a technology in one period may consider using it in the future if they are aware of it far enough in advance. Even for technologies like Paro or the Home Monitoring System, which might be useful in the severe stages, manufacturers, health care workers, and service providers would still do well to inform and educate consumers about them early on, so that caregivers are aware of them and can weigh whether and how these technologies might be of use to them. Early education would also allow consumers to have more time to overcome any barriers to acceptance and adoption involved in learning to use a new technology, as well as to consider any other costs (for instance, financial) of technology adoption[8].

Limitations

This study is not without limitations that preclude generalizing the results to the larger population. First the sample size is quite small and limited to caregivers in the metro-Boston area. Further, the sample is heavily female dominated and dominated by those caring for loved ones with moderate dementia. Future research should attempt to replicate this technology survey with a larger group of caregivers that is more balanced by gender and dementia stage of the care recipient. Another limitation of the study was the use of descriptions of technologies rather than actual technologies; the concepts of perceived usefulness and perceived ease of use might be better captured and examined if participants could interact with the technologies themselves. Furthermore, in some cases, the care recipients were present during the interviews, which may have influenced some of the caregivers' responses. Finally, this study was cross-sectional, but it would be preferential to examine these questions with a longitudinal study so researchers could follow up with participants and determine which, if any, technologies participants actually adopted.

Conclusions

To increase technology use among caregivers with the goal of reducing their burdens of care requires a greater understanding of awareness and willingness to use the technology. Technology adoption is a process, not simply a dichoto-

mous choice that caregivers face. As we change and evolve, so do our needs, technology that may not be useful to us at a given point in time may be later. Lee and Coughlin[8] argued that technology adoption depends on four domains: (i) individual user characteristics; (ii) design and functional features of the technologies that affect how users interact with them; (iii) social and environmental expectations or needs arising from the setting in which the technology is used; and (iv) delivery features around the communication and distribution channels of the technology. Technology adoption depends on the interplay of these four, and the failure to adopt a technology should not necessarily be seen as scoring low in each of these four areas.

Adoption depends first on awareness and then evolutions within each of the domains. Users' needs or abilities may evolve or change over time, and so too may the perceived use they see for a given technology. A technology itself may evolve, changing how it is available to consumers, how much it costs, as well as how it is physically designed. Social stigma or value attached to using a given technology may also change over time. Users may not want to use technologies until these four domains align for them. Future research should consider not just the different stages of this process but also environmental factors such as participants' living environments, the services they use, and psychological variables such as personality traits to augment our understanding of their perceptions around technology. Ideally, we also need more work to observe actual adoption and integration of different technologies into the home care environments of patients at different disease stages. The environment in which caregivers operate is an extreme and stressful one, and while the gains from incorporating technology into care may be great, so too may be the costs involved in learning to use and adding new technologies into the care context.

Despite the limitations of the study, the results emphasize the importance of awareness in technology acceptance and adoption. Further, an analysis of attitudes toward emerging technologies yielded findings consistent with Davis's TAM model[20], highlighting the importance of both perceived usefulness (which proved to be more important, in keeping with the model) and perceived ease of use to users. The study shows that caregivers are interested in emerging technologies, but there are clearly barriers around awareness of any new AT as well as a need to inform caregivers and people who advise them around care related affairs effectively about how these different technologies may help with providing or supporting care. As the baby boomers age, it is critical not only that designers develop and produce new technologies to meet emerging needs, but that the information about these - and their potential benefits - are communicated successfully to those who need them most.

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