

# Older Adult Perceptions of Smart Home Technologies: Implications for Research, Policy & Market Innovations in Healthcare

J.F Coughlin, L.A. D'Ambrosio, B. Reimer, M.R. Pratt

Massachusetts Institute of Technology AgeLab, 77 Massachusetts Avenue, E40-279  
Cambridge, MA 02139 USA

**Abstract**—Advances in information communications technology and related computational power are providing a wide array of systems and related services that form the basis of smart home technologies to support the health, safety and independence of older adults. While these technologies offer significant benefits to older people and their families, they are also transforming older adults into lead adopters of a new 24/7 lifestyle of being monitored, managed, and, at times, motivated, to maintain their health and wellness. To better understand older adult perceptions of smart home technologies and to inform future research a workshop and focus group was conducted with 30 leaders in aging advocacy and aging services from 10 northeastern states. Participants expressed support of technological advance along with a variety of concerns that included usability, reliability, trust, privacy, stigma, accessibility and affordability. Participants also observed that there is a virtual absence of a comprehensive market and policy environment to support either the consumer or the diffusion of these technologies. Implications for research, policy and market innovation are discussed.

## I. NEW DEMANDS OF AN AGING SOCIETY

AGING is the social factor shaping the future of the vast majority of nation's today. A combination of longer life and decreased fertility rates are driving a demographic transition from the once 'normal' population distribution of many young people with few older people to a distribution that reflects many more people over age 50 than there are children. Industrialized economies, primarily Organization for Economic Cooperation and Development or OECD states will face accelerated aging when the baby boomers of North America and Europe and Danka of Japan begin turning 65. Europe, already with more older people than children, will have twice the number of elderly than children by 2050. Even developing economies, such as China, are now facing a virtual geriatric explosion with nearly 140 million people already over 60. In fact, the United Nations

revised World Population Prospects estimates that by 2045 humankind will have set a historical first where the number of people over age 60 will be greater than the number of children under age 15.

The unprecedented rate of aging, along with the demands of an older society will reshape every aspect of daily life. Clearly, health will receive more attention and require even more innovation to ensure its quality and cost-effective delivery. Increasing emphasis will be placed on disease management to improve the quality of life of older people as well as to manage the exponential increase in costs associated with common chronic conditions, e.g., diabetes, hypertension, and wide range of cardio-vascular diseases. Exploding rates of chronic disease in North America and Europe alone portend a disease burden that could drive unprecedented demands on healthcare systems, private and public insurers, disability and lost workplace productivity.

## A. Convergence of Aging, Health & Smart Home Technology

Only equal to the rate of aging has been the rapid development of advanced technology. The creative application of new technology to healthcare has received considerable attention from researchers and investment from both business and government. Biomedical, diagnostic technologies and other applied areas are greatly improving the lives of older people. Other technologies are being developed to improve health as part of daily living in the home, at work or in some instance, even the car. Robotics, for example, is offering the possibility of 'carebots' to assist older people with activities of daily living from dressing, cleaning the home, to reminding them to take medication [1].

Information communications technology or ICT is perhaps the richest area to produce new ideas to support the health of older adults. ICT is being used to monitor, manage and motivate a new generation of healthcare for older people [2]. For example, sensors, related algorithms and attending call centers form the basis of 'smart home health' technologies providing families and formal caregivers with the capacity to remotely monitor the wellbeing of an older adult living at home [3]. Pervasive computing applications are available to predict a fall based upon a change in gait, rather than simply

Manuscript submitted for review April 30, 2007.

Joseph F. Coughlin is Director of the Massachusetts Institute of Technology AgeLab, 77 Massachusetts Avenue, E40-279, Cambridge, MA 02139 USA. (phone: 617-253-0753; fax: 617-258-7570; e-mail: coughlin@mit.edu).

Lisa D'Ambrosio, Research Scientist, MIT AgeLab, 77 Massachusetts Avenue, E40-291A, Cambridge, MA 02139 USA.

Bryan Reimer, Research Scientist, MIT AgeLab, 77 Massachusetts Avenue, E40-291, Cambridge, MA 02139 USA.

Michelle Pratt, Research Associate, MIT AgeLab, 77 Massachusetts Avenue, E40-291A, Cambridge, MA 02139 USA.

report a disaster after the often fatal event has occurred. Telemedicine or telecare is increasingly common providing connectivity with clinicians to improve the management of chronic disease in the comfort of an older person's home rather than in the costly surroundings of a hospital [4-6]. Other devices from the ubiquitous cell phone to intelligent everyday devices such as cabinets, picture frames, kitchen appliances and toilets are being used to motivate people to adhere to diets, take medication or to exercise. Technology is now available to transform the older adult into a lead adopter of an emerging 24/7 healthcare envelope of care.

## II. IMPACT OF OLDER USER PERCEPTIONS ON COMMERCIALIZATION OF TECHNOLOGY

### A. From Invention to Innovation

Although ICT applications and related technologies have been available for many years, major corporations and governments have only recently given significant attention to the promise of technology to improve the lives of older adults. Recent interest, along with the profound change in demographics, suggests that 'technology and aging' is moving toward the tipping point where interest will translate into investment to move countless inventions that exist in the laboratory into innovations in living [7].

However, availability of technology and obvious need may not translate into commercial opportunity or policy success. For example, personal emergency response services, or PERS, sometimes referred to as social alarms, have been available for several decades. Likewise, telemedicine devices to monitor selected diseases such as congestive heart failure or diabetes have been selectively used for many years. Neither has enjoyed widespread adoption in any country. Lau examined the penetration of PERS in the United States. Despite its availability, affordability and ease of use, Lau estimates that less than 5 percent of older Americans that could benefit from these systems have adopted them. Even in the United Kingdom, where PERS are fully subsidized by the National Health Service, adoption is only 15 percent [8].

### B. Consumer Perceptions as a Barrier to Health Technology Adoption

If systems that are readily available and affordable are not translating into innovations in living, what are the prospects for the coming generation of inventions designed for older adult health? One possible explanation is that the perceived value of technology-enabled health applications are not responding to older consumer demands [9].

A variety of hypotheses addressing older consumer adoption of technology are available. These range from classic questions of usability to technology equity issues that strongly suggest the existence of a digital divide between adopters and non-adopters of technology [10].

Usability remains an important issue to adoption. While improvement have been made in design the user friendliness of devices remains a challenge. In addition to somewhat obvious characteristics, such as font size, controls for arthritic hands, research suggests that more work needs to be conducted to address the most effective mental model to guide the user's expectation of how the device may work [11].

Related to usability and practical use is the perceived 'hassle factor.' The related logistics associated with installation, correct use, maintenance, etc., may be just great enough to outweigh the possible benefits of inviting new technology into an older person's daily routine [12].

Other research indicates that uneven adoption may be the result of education and technological efficacy on the part of the user. Arguing that adoption of home health systems may be another indicator of an underlying digital divide among older adults [13]. In related research Aminzadeh, et al, suggest that education or simply getting the word regarding the availability of technology and assistive devices may be a critical barrier to adoption [14].

Perhaps the most potent factor affecting the success or failure of technology adoption by older adults addresses how user's feel about what adopting the technology may say about them. For example, does adoption of a device-enabled service to monitor my wellbeing and medication adherence trample my privacy and independence in the name of safety and security. Is technology assisting me or replacing my own sense of self-control and confidence? Moreover, does the presence of these technologies in my home 'label' me as frail. Mann, et al., found that many older adults perceived that technology offered considerable promise for those who need the service – however, few thought they were among those that needed such assistance [15-18].

### C. Motivation

The primary motivation was to better understand technology adoption by older adults so to inform and improve technology and service development; and, to identify the possible role of public policy and market innovations to promote the availability and diffusion of effective technologies. Therefore, two dimensions of technology adoption by older adults were examined. The first was to validate the findings of previous work and to discover any other user concerns influencing technology adoption. The second was to identify policy or market factors that go beyond the individual but have a critical impact on the speed of technology diffusion into the lives of older people.

### III. METHOD

#### A. Workshop – Focus Group

A workshop and focus group were conducted with 30 aging services leaders and aging policy advocates over a five hour period in December 2005. The first half of the session entailed a workshop format where laboratory researchers presented a variety of commercially available and still under development technologies ranging from telemedicine systems, smart scales, health kiosk systems, personal advice systems to guide diet, home monitoring concepts as well as selected ‘toy’ and play ideas to enhance medication adherence. Participants were encouraged to ask questions, experiment with the devices and offer their own critique or experiences with similar technologies.

After the workshop, participants reconvened in an adjacent conference room for a focus group discussion on their perceptions and possible concerns with the use of technologies in the lives of older adults. A focus group is a structured discussion moderated by a facilitator to elicit qualitative information regarding the perceptions, language, emotions and thought processes of the participants on a selected topic. Focus groups provides an excellent basis for exploratory research and hypothesis development [19].

The group discussion was moderated by one of the authors of this study while two other authors took notes and summarized the exchange.

The following questions were used to guide the conversation and to stimulate discussion over a two hour period:

Which technologies did you see or hear about today – or do you know about from other sources – that you think could be helpful in addressing some of the most pressing problems of older people in your state or region?

- In what ways would they be helpful?
- Which would you like to see come to market and be widely distributed first?

What kinds of barriers or problems do you see with adopting and using some of these technologies, e.g., legal, regulatory, social and individual barriers. For example, are there laws or regulations in your state that would make adopting these technologies problematic? Do you foresee a great deal of resistance among older consumers in using the technology?

- Privacy and security versus convenience
- Cost of technology – to the individual and to state/local government
- Individual resistance to using technology – is this because of fear or a reluctance to learn new technologies, or do people feel like they are too removed from human and social contact with others?

#### B. Participants

Participants in the workshop and focus group included 30 aging services leaders and state and Federal-level policy advocates based in the Northeastern United States and Washington, DC. Of the 30 participants, 17 were women and 13 were men. The age distribution was between 40 and 75. At least two representatives from statewide aging advocacy groups from Maine, New Hampshire, Vermont, New York, Massachusetts, Rhode, Island, Connecticut, New Jersey, Pennsylvania and Delaware attended.

The participants presented a unique opportunity to capture the ‘elite’ opinions of service providers and policy advocates representing millions of older adults in the Northeastern United States. Moreover, they are well equipped to address our second motivation to better understand policy and market issues affecting home health technology adoption.

#### C. Analysis

Following the focus group, notes were compiled, compared and summarized by the authors. General themes, frequently mentioned topics and related issues were identified and documented. Although there was an attempt to ascertain if there were differences between states and between state and Federal advocates, there were no clear differences identified. There were selected individual differences between the participants with respect to the intensity that they may have articulated on a specific topic, e.g., importance of cost of technology vs. compromise of privacy.

### IV. FINDINGS

#### A. Themes

The participants identified a wide variety of issues. Generally these issues fit into four themes. As Table I summarizes, these themes included multiple elements. The four themes included questions around Technology Design; Ethical Considerations; User Perceptions; and, The Prospective Role of Markets & Public Policy.

Technology Design	Ethical Considerations	User Perceptions	Role of Markets & Policy
- Functional - Reliability - Usability	- Privacy - Trust - Loss of Dignity	- Safety v. Independence - Designed for ‘Old’ - Stigma	- Access to Technology - Equity & Affordability - Absence of Federal & State Policy

Table I. Categorization of Older Adult Perceptions of Smart Home Technologies

## *B. Technology Design*

Participants voiced a number of concerns regarding the design of new technologies to be used in the home. First, was the most basic question of use and functionality. There was a general consensus that there was an inadequate awareness in the aging community, among both users and the advocates for the elderly, of what technology exists and what the capabilities might be. Equally unclear is how any of these capabilities truly improve a person or a family's life. Paraphrasing one participant, "how do I know that these things (medical devices) will actually work in my home as well as they work in the store?"

System reliability was also identified as a concern. That is, even if a device worked, would it perform when it was most needed? As one participant observed, referring to congestive heart monitoring systems, "these gizmos are going to be providing help to the most vulnerable and in need, how can we be sure that they will they work in an emergency?" Clearly, trust or predictability of technologies and related services is an important issue for all users, but perhaps most critical for an older consumer who is more likely to be frail and managing a condition with less resilience than a younger person, e.g., living alone or managing physical limitation [20].

As highlighted in previous studies, basic usability remained a concern. A few participants thought that technologies were "too difficult for older people to use and were best suited for their children to help take care of them." Understanding how to use was equal to the challenges of being able to see LCD displays and manipulate buttons and switches. While the physical usability of displays are important, the discussion highlighted basic challenges around design that facilitated understanding, trust and how best to anchor the function of the device into a familiar mental model or metaphor that the older user could use as their guide in learning a new device.

## *C. Ethical Considerations*

Ethical considerations were the most passionately discussed, and perhaps, the most frequently mentioned concerns identified by the group. The two dimensions most highlighted were privacy and trust. Participants were very concerned that technologies were being developed to perform functions, e.g., 24/7 home monitoring, "because the technology can do it" rather than it was necessary or desirable. More than one of the group questioned if there were any ethical or value-based foundations that technologists were using to inform the development of these systems. According to one participant, "ethics should be used as veto point to decide between what we can do and what we should do."

The idea of ethics as a "bedrock" to determine how best to use smart technologies in health was most discussed when the issue of privacy was identified as a major concern. How much personal information was going to be collected and

"who would both manage and have access to these data" was a significant issue with all participants. While it was assumed that existing Federal law, e.g., HIPAA would govern some of the data and related services, many of the participants were concerned that the same data that could be used to motivate older adults to eat correctly or take their medications could be used to penalize people for not complying with prescribed health regimens. For example, would health insurers use these behavioral data to price insurance or to levy a 'surcharge' on poor health behaviors.

Participants devoted considerable time to "where does an individual's rights start and stop." This part of the discussion focused on a thematic question – if data are available to improve their health and healthcare overall, should it be used – and to what extent, if it risks individual rights? Some passionately argued that as more medical data is collected it will only increase the likelihood that it will be abused by healthcare providers to reduce costs at the 'expense' of the older consumer.

Although less of a concern, other participants suggested that they worried that these data might be used as part of an intrusive marketing strategy. Contrary to their original purpose, smart home technologies that were designed to support the health and safety of older adults could then be abused by retailers or other vendors simply interested in the older consumer market.

## *D. User Perceptions*

While all the participants were intrigued by the potential of smart home technologies to support health and long-term independence, they did have some perceptions that may explain relatively slow adoption of many of these devices and related services. First, was the thought that many of the technologies offered considerable promise in improving personal safety but at considerable cost – not to income but to independence. Many saw the loss of privacy and 24/7 monitoring as a way to ensure safety and security but an "equal threat to dignity in one's own home." Consensus of the group was even if affordable, these systems may cost the individual too much unless they are extremely frail or the only other alternative may be nursing care or living with an adult child.

A closely related perception was that smart technologies in the home may be designed for the oldest old and not younger or more healthy older adults seeking to simply age-in-place. This perception may be a significant barrier to technology adoption because as the group admitted few adults of any age see themselves as 'old' and even fewer see themselves as frail. Consequently, some of the participants thought that smart technologies may be a "stigma to some older people" and more symbolic of their frailty than of their supported independence and health.

### E. Role of Markets & Public Policy

Previous work conducted on technology use and adoption has focused on the consumer experience exclusively. This group of aging and aging services advocates provided unique insight into the possible role of markets and public policy.

Participants had considerable questions about how smart technologies and related services would find their way into the home. Who would offer these technologies and services? If industry provided these innovations, would it be through pharmaceutical companies, retailers or private insurers? What would the role of the physician and hospital be in “prescribing” the appropriate array of technology and services?

In addition to questions of how these systems would be offered or purchased, participants expressed concerns about standards of performance and quality. Would government play a role as ‘honest broker,’ if not who would help the older consumer or their family choose the right technology and appropriate services? Moreover, how might the benefits of high technology be made available to those of low income? As one participant exclaimed – “are we only building technologies for the rich?” With respect to both concerns of consumer protection and equity, participants noted that to their knowledge there was little or no public policy at the state or Federal level promoting smart home technology adoption or affordability (in contrast to R&D) for an aging population.

### V. CONCLUSIONS & FUTURE RESEARCH

Advances in smart home technologies offer considerable power and promise to improve the health and wellness of older adults aging-in-place and help to caregivers supporting frail elderly. All participants embraced the further development and commercialization of these technologies. However, a variety of concerns including usability, reliability, privacy and affordability were identified as possible barriers to adoption. In addition, while age is a critical factor, additional research should be done to understand how the use of ICT and related technology-enabled services are impacted by the wide range of socio-economic and cultural factors that exist in today’s and tomorrow’s older population. These findings validate previous research on technology adoption by older adults. However, this exploratory work reveals a new area worthy of further examination – how might institutional innovation occur to move inventions in the laboratory into the living rooms of older adults? For example, are state or Federal actions required to ensure equity as well as the existence of an ‘honest broker?’ Future research should also examine what creative financing and technology-enabled services might be offered through trusted providers, e.g., affinity groups, neighborhood associations, local government, banks, utilities, retail pharmacies, or insurers.

### ACKNOWLEDGMENT

The author’s wish to thank those that participated in the technology workshop and focus group. We also extend our thanks to Ms. Paula Magliozzi, MIT AgeLab for preparation and submission of this manuscript. The authors gratefully acknowledge an unrestricted grant from AARP and Healthways which supported this research.

### REFERENCES

- [1] I. Korhonen, J. Parkka, and M. Van Gils, “Health monitoring in the home of the future,” *IEEE Engineering in Medicine and Biology Magazine*, vol. 23, no. 3, pp. 66-73, May/June 2003.
- [2] D.L. Hudson and M.E. Cohen, “The role of information technology in disease management,” in *Proc. 4<sup>th</sup> Annual IEEE Conference on Information Technology Applications in Biomedicine*, 2003, p. 169-172.
- [3] P.M. Orr, M.A. McGinnis, L.R. Hudson, S.S. Coberley, A. Crawford, J.L. Clarke, and N.I. Goldfarb, “A focused telephonic nursing intervention delivers improved adherence to A1c testing,” *Disease Management*, vol. 9, no. 5, pp. 277-283, 2006.
- [4] D.L. Hudson, G. Brent Hamar, P.M. Orr, J.H. Johnson, A. Neftzger, R.S. Chung, M.L. Williams, W.M. Gandy, A. Crawford, J.L. Clarke, and N.I. Goldfarb, “Remote physiological monitoring: clinical, financial, and behavioral outcomes in a heart failure population,” *Disease Management*, vol. 8, no. 6, pp. 372-381, 2005.
- [5] R.W. Pew and S.B. Van Hemel, Eds., *Technology for adaptive aging*, Steering Committee for the Workshop on Technology for Adaptive Aging, National Research Council, 2004.
- [6] J.F. Coughlin, J.E. Pope, and B. R. Leedle, Jr., “Old age, new technology, and future innovations in disease management and home health care,” *Home Health Care Management & Practice*, vol. 18, no. 3, pp. 196-207, 2006.
- [7] J.F. Coughlin, “Technology needs of aging boomers,” *Issues in Science and Technology*, 1999.
- [8] J. Lau, “Building a national technology and innovation infrastructure for an aging society,” S.M. Thesis, Technology and Public Policy Program MIT, 2006.
- [9] J.F. Coughlin and J. Lau, “Cathedral builders wanted: constructing a new vision of technology for old age,” *Public Policy & Aging Report*, 16(1), 4-8, 2006.

- [10] E. Kim, A. Mayani, S. Modi, C.B. Soh and Y. Kim, "Evaluation of patient-centered electronic health record to overcome digital divide," in Proceedings of the IEEE EMB 27<sup>th</sup> Conference, 593, 2005.
- [11] G. Demiris, M. Rantz, M. Aud, K. Marek, H. Tyrer, M. Skubic and A. Hussam, "Older adults' attitudes towards and perceptions of "smart home" technologies: a pilot study," *Medical Informatics and the Internet in Medicine*, 29(2), pp. 87-94, June 2004.
- [12] M. Engstrom, R. Lindqvist, B. Liunggren and M. Carlsson, "Relatives' opinions of IT support, perceptions of irritations and life satisfaction in dementia care," *J Telemedicine and Telecare*, 12(5), pp. 246-250, 2006.
- [13] D.R. Kaufman, V.L. Patel, C. Hilliman, P.C. Morin, J. Pevzner, R.S. Weinsack, R. Goland, S. Shea and J. Starren, "Usability in the real world: assessing medical information technologies in patients' homes," *J Biomed Inform*, vol. 36, pp. 45-60, 2003.
- [14] F. Aminzadeh and N. Edwards, "Exploring seniors' views on the use of assistive devices in fall prevention," *Public Health Nursing*, 15(4), pp. 297-304, 1998.
- [15] G. Demiris, M. Rantz, M. Skubic, M. Aud, and H. Tyrer, Jr., "Home-based assistive technologies for elderly: attitudes and perceptions," in AMIA Annual Symposium Proceedings, 935, 2005.
- [16] A.F. Long, T. Gambling, R.J. Young, J. Taylor, and J.M. Mason, "Acceptability and satisfaction with a telecarer approach to the management of type 2 diabetes," *Diabetes Care*, 28(2), pp. 283-289, 2005.
- [17] W.C. Mann, T. Marchant, M. Tomita, L. Frass, and K. Stanton, "Elder acceptance of health monitoring devices in the home," *Care Management Journal*, 3(2), pp. 91-98, Winter 2001-2002.
- [18] M. Roelands, P. Van Oost, A. Buysse, and A. Depoorter, "Awareness among community-dwelling elderly of assistive devices for mobility and self-care and attitudes towards their use," *Social Science and Medicine*, 54(9), pp. 1441-1451, May 2002.
- [19] R.A. Krueger and M.A. Casey, *Focus groups: a practical guide for applied research*, Thousand Oaks, CA: Sage Publications, 2000.
- [20] T. Sheridan, J.F. Coughlin, D. Kim, and J. Thompson, "Communication in health care tactics for older adults: the case for heart patients," in W. Rogers and A. Fisk (Eds.), *Human factors interventions for the health care of older adults*, London: Lawrence Erlbaum, pp. 203-219, 2001.