The Current State of Technology in U.S. Health Care Services for Elders

Sunghee H. Tak, PhD, RN[1], Lazelle Benefield, PhD, RN[2], Diane Feeney Mahoney, PhD, APRN, BC FGSA[3]

Introduction

Recently developed technology products and research suggest that new technology solutions may make aging services more efficient, effective, and user-friendly. A growing number of service providers, government policy makers, manufacturers, and researchers in the U.S. assert that technologies have the potential to control healthcare demands of growing older population, revolutionize the way we care for the aging population, and improve the quality of life for the elderly. This article will review the current state of technology in U.S. healthcare services for elders and highlight the potential benefits of technology on improving their quality of life.

1) Assistant Professor, College of Nursing, University of Arkansas for Medical Sciences
2) Professor and Parry Chair in Gerontological Nursing, College of Nursing, University of Oklahoma Health Science Center
3) Jacques Mohr Research Professor in Geriatric Nursing & Director of Gerontechnology, Graduate Program in Nursing, MGH INSTITUTE of Health Professions
E-mail: Taksunghee@uams.edu

Driving forces for technology adoption in aging services

Two major factors in the U.S. have converged to favor technologies as a "Linchpin" (Center for Aging Services Technology, 2003) in leading the transformation of aging services. First, older population has become technology savvy. They have higher levels of education, income, and standards of living then their parents did (National Institute of Health, 2006). Currently, about eight million Americans age 65 or older use the Internet, with an equal distribution among males and females (Fox & Pew Internet & American Life Project, 2004). The percentage of seniors who go online has jumped by 47% between 2000 and 2004. Online older users send e-mails (87%), find information (61%), read news (55%), do shopping (32%), and play games (29%) (U.S. Census, 2001). Technology increasingly plays a vital role in the lives of older adults.

Second, the efforts of advocacy organizations, government, business, and research academe to deploy technology in aging services are growing fast. In 2003, a national coalition of more than 400 technology companies, service organ-

izations for elders, research universities, and government representatives formed the Center for Aging Services Technology (CAST), under the auspices of the American Association of Homes and Services for the Aging. CAST has been a leading force and played a key role in the White House Conferences on Aging (CAST, 2003, 2005). Recent reports from U.S. government offices emphasize the essential role of technology in future healthcare for the aging population (Brailer, 2005; U.S. Office of Technology and Policy, 2005; U.S. Office of Disability, Aging and Long-Term Care Policy, 2005). The Department of Veterans Affairs (VA), the nation's largest network of aging-related services, is a leader in introducing technology for the older population. A VA home monitoring system has enabled veterans to send health information electronically to their nurses who then provide the veterans with feedback and advice. The system includes video-phones, in-home messaging devices, and personal computers with interactive chat rooms (Linkous, 2005). A report from the Office of Disability, Aging and Long-Term Care (LTC) Policy of the U.S. Department of Health and Human Services (DHHS) (2005) discussed current technologies relevant to LTC, identified barriers to implementing technology in residential LTC settings, and proposed strategies to overcome the barriers. More than 125 leaders and stakeholders participated in the 2005 LTC Health Information Technology Summit with a vision in which the adoption of health information technology offers new opportunities to realize and extend person-centered care (American Health Information Management Association, 2005). The summit discussed priorities for LTC health information technology, built consensus on key action items and a road map, and developed an agenda for focusing private and public sector efforts on promoting and implementing electronic health records and other information technologies in LTC settings. The summit emphasized person-centered care and a need for consumer engagement in all aspects of healthcare delivery.

Further, major technology companies (e.g., Intel) have begun to investigate a broad range of technology products and innovative solutions to meet the needs of elders with cognitive and functional disabilities. The majority of the technology applications are in the concept-for-test, prototype, and development phases. A few specialized retail outlets and catalogs already offer some products. Many technology products and solutions originally developed for home-based or acute-care have potential applications in residential long-term care. The technologies are expected not only to increase the efficiency of care delivery but also to improve the quality of life for residents in long-term care setting such as nursing homes. Businesses and non-profit organizations also are involved in initiatives targeting the population to increase knowledge and skills in technology (Mahady, 2002). For example, the Internet Accessibility Project, a partnership between American Telephone & Telegraph (AT&T) and International Business Machines (IBM), funded two non-profit organizations: Generations-on-Line and SeniorNet.

Generations-on-Line develops software and training guides specifically for elders who are unfamiliar with computers. More than an estimated 25,000 individuals have used their training materials (Generations-on-Line, 2006).

SeniorNet provided technology training to over 100,000 older adults at learning centers throughout the U.S (SeniorNet, 2004). A total of 1,020 facilities, including nursing homes, senior centers, libraries, and SeniorNet learning centers, participated in the project. Other organizations such as CyberSeniors and the American Association of Retired Persons (AARP) are providing basic computer and Internet training to older persons (Morgan, 2005). <Table 1> describes programs of major governmental agencies, organizations, and businesses, that are driving forces in aging technology.

In addition, universities (e.g., Massachusetts Institute of Technology) nationwide are responding increasingly to technology needs in aging services by organizing programs of study and undertaking research in gerontology and geriatrics. The National Institute of Aging has established the Edward Roybal Centers for Research at 10 universities. The Roybal Centers facilitate the translation of basic science into practical outcomes, including new technologies, for the benefit of elders. Twenty-two universities have Rehabilitation Engineering Research Centers (RERCs) funded by National Institute for Disability and Rehabilitation Research (NIDRR)'s grants in conjunction with the U.S. Department of Education. The RERCs that focus on aging include the University of Florida (RERC on Technology for Successful Aging) and Wisconsin's Trace Center (RERC on Universal Interface and Information Technology Access, and Telecommunications Access). Other RERC research programs that have aging technology applications can be found at the University of Buffalo (focuses on "smart" housing) and University of Colorado (RERC for Advancing Cognitive Technologies). <Table 2> presents selected research programs in U.S. based universities.

< Table 1 > Examples of Driving Forces of Technology for Elders

U.S. Government	Office of Disability, Aging and Long-Term Care Policy, DHHS Office of Technology Policy, Technology Administration, Department of Commerce Department of Veterans Affairs Agency for Healthcare Research and Quality National Institute of Standards and Technology Department of Education National Institutes of Heal
Agencies and organizations	Center for Aging Services Technologies, American Association of Homes and Services for the Aging American Health Information Management Association Healthcare Information and Management Systems Better Health Technologies, LLP, and Forrester Research Markle Foundation and Robert Wood Johnson Foundation Alzheimer's Association Polisher Research Institute and IDEAS, Inc

	Health Technology Center and Manatt, Phelps & Phillips, LLP National Alliance for Health Information Technology California HealthCare Foundation and Critical Mass Consulting Home Care Information Technology Council
Industries and businesses	Intel's Proactive Research Project and the Applications, Interfaces, and Media (AIM) Health Honeywell Automation and Control Solutions, Advanced Applications Laboratory Companies that involve in CAST: Bayer, Best Buy, Comcast, General Electric, Hewlett-Packard Company, Intel, Honeywell, KPMG, Medtronic, Phillips, Panasonic, Samsung Advanced Institute of Technology, Scan Health Plan, Siemens, and Tyco International Approximately 270 manufacturers and distributors of LTC technology were identified by the U.S. Office of Disability, Aging and Long-Term Care Policy

< Table 2 > Selected Research Programs in U.S. based universities

Universities/Centers	Description
MIT	MIT's "AgeLab" is one of the nation's leading centers of technology research and development for aging applications. Examples of the lab's health-related projects include "Pill Pets", electronic toy pets for medication taking, "digital danskin" to monitor health using bio-sensors, and Alzheimer's disease and wandering safe return service: web.mit.edu/agelab
Georgia Institute of Technology	The Aware Home Research Initiative (AHRI) includes projects on social communication ("Digital Family Portrait" and "Dude's Magic Box"), memory aids ("Cook's Collage" and "Memory Mirror"), and everyday home assistants ("Gesture Pendant"). The Initiative also explores "indoor location service" and "activity recognition" in a living laboratory of a three-story home: www-static.cc.gatech.edu/fce/ahri/projects/index.html
University of Florida	The "Gator-Tech Smart House" is one of the most progressive applications of pervasive computing and renovates the concept of housing. The Gator-Tech Smart House designs each room and part of the house, including blind, smart phone, bed, bathtub, soap, mirror, toilet, shower, social distance dining, refrigerator, laundry, and more, with "smart technologies." Other projects include the VA's tele-homecare demonstration and a website developed for caregivers of persons with AD: www.icta.ufl.edu/gatortech/index2.html and www.alzonline.net
University of Colorado	The RERC-ACT focuses on applied assistive technology for people with cognitive disabilities. Projects with aging applications include "Design,

Universities/Centers	Description
	Implementation and Deployment of Context Aware Technologies", "Lifeline", "Memory Aiding Prompting Systems (MAPS)", "Cellular Engineering Micro Systems (CEMS)-Based Chronic Brain Implant", and "SmartCare Project": www.colemaninstitute.org/about.php
Consortium of University of Pittsburgh, University of Michigan, National Aeromautics and Space Administration Johnson Space Center, and AT Sciences	The consortium involves projects related to memory aids, activity assistant, and cognitive orthotics. The "Solo" allows a caregiver/staff to organize an elder's tasks into a daily schedule and instructs him/her on how to perform the tasks. It provides automatic assistance in revising the elder's schedule as situations change (e.g., tasks run over expected times or need to be rescheduled). "Autoreminder" is another adaptive cognitive orthotic that can send a reminder on a mobile robot or run on a handheld computer. The "nursebot" named Pearl assists elders in activities of daily living: www-2.cs.cmu.edu/~nursebot. .
Oregon Health and Science University	The Oregon Roybal Center for Aging, Technology, Education & Community Health (ORCATECH) facilitates pilot studies to use emerging technologies in aging. The "MedTracker", an intelligent pill box, recognizes if a user needs help with medication. The "Point of Care Laboratory" consists of artificial intelligence algorithms that combine information from a variety of sensors and tracking devices placed throughout the homes of seniors, assesses situations involving possible mobility or cognition problems, and provides health coaching to a user. Intelligent walkers and canes detect balance changes and sound alerts or signals to encourage appropriate use. Beds equipped with weight sensors track sleep patterns, and strategically-placed sensors track movement in homes. Adaptive computer games monitor cognitive performance and potentially improve an individual's cognitive skills: www.sciencedaily.com/releases/2005/12/051214082310.htm or www.ohsu.edu/alzheimers/roybal/
University of Virginia	The Medical Automation Research Center focuses on automation and robotic solutions to provide healthcare. The "In-home Monitoring System (IMS) and Sleep Monitoring System" comprise a set of wireless proximity infra-red sensors to monitor and detect vital signs, motion activities, activities of daily living, and sleep behaviors. The "Robotic Walker" is an intelligent automated assistive walking device: marc.med.virginia.edu/projects.html
University of Washington	The assisted cognition project combines "computer science research in artificial intelligence and ubiquitous computing with clinical research on patient care." The "Project ACCESS" supports persons with cognitive disabilities to find directions and locations, using a GPS-enabled

Universities/Centers	Description
	cell-phone with a remote monitoring and reasoning system. The "SHARP (a System for Human Activity Recognition and Prediction)" project is related to daily activity monitoring: www.cs.washington.edu/assistcog/
University of Rochester	The Center for Future Health has developed "Chester the Talking Pill", an avatar technology embedded into a medicine cabinet. When a user opens the medicine cabinet, "Chester" asks people questions, checks data bases of physician instructions, medication schedules and potential interactions among drugs, and provides advice via a pop-up video on a computer screen. The Center also is developing "Automated Health Assessment" systems: www.futurehealth.rochester.edu
Center for Research &Education on Aging &Technology Enhancement (CREATE)	CREATE is a consortium of the University of Miami, Florida University, and Georgia Institute of Technology and conducts research on human interaction with technology. Activities examine "user needs and preferences, identify problems with existing systems, and explore the efficacy of potential design solutions" to enhance the ability of older people to use technologies: www.med.miami.edu/psychiatry/create.html
MGH Institute of Health Professions	The Gerontechnology lab & Partners Telemed Connected Health Initiative explores feasibility, usability, and interventions of multiple innovative technologies in real world geriatric home, business, and care settings. The Initiative concerns design for end-users (e.g., family, LTC residential staff, & elders), comparison of wireless sensor monitoring and nurse online discussion group outcomes, and willingness to pay for technology (Mahoney, 2000, 2004; Mahoney, Tarlow, Jones, Tennstedt, & Kasten, 2001 www.mghihp.edu) as wellas teledermatology and consultant medical services via the Internet (www.telemedicine.partners.org)
University of Oklahoma	Research studies describe and prioritize caregiving concerns of distance caregivers of cognitively impaired elders living alone at home or in LTC facilities and identify current and emerging technology interventions to address priority caregiving concerns.
University of Arkansas for Medical Sciences	Research studies examine theeffects of Therapeutic Computer Activity Interventions on cognition, affect, depression, and agitated behaviors among persons who have cognitive and functional disabilities and reside in LTC settings (Tak, Beck, Buettner, & Clark, 2005; Tak & Beck, 2005)

Progresses and Challenges

Technology has potential to support activities of daily life and enriches the lives of elders ranging from safety (falls, wandering) to self-care activities (bathing, medication, eating, mobility, sleeping) to communication (social interaction and connection) to entertainment (recreation, leisure). Principles that guide the development and use of technology include assessing while helping, adapting assistance to variability in cognitive and functional abilities, catalyzing instead of replacing social interactions, and using familiar interfaces (Morris and Lundell, 2003).

On the horizon is ubiquitous computing, or the era of calm technology, when technology recedes into the background of our lives (Weiser, 1996). The first era in computing consisted of mainframes shared by lots of people. Now we are in the personal computing era with person and machine staring uneasily at each other across the desktop. Ubiquitous, pervasive, and proactive computing represents the third era in computing, just now beginning. They are unobtrusive, preventive, personalized, and remote. Some of high-tech options may include: wireless broadband; biosensors and bodily diagnostics; activity sensors and behavioral diagnostics; information fusion; personal health informatics; ambient displays and actuator networks; agents, assistants, coaches, and companions; adaptive, distributed interfaces; and remote community and collaboration (Dishman, Matthews, & Dunbar-Jacob, 2004). These enabling, automation and embedded technologies in use in the community or acute care setting have potential applications in residential care settings such as nursing homes ("Computer-based technology and caregiving for older adults. Special National Conference Report", 2003).

These technologies offer strong assistance for safety and monitoring, managing everyday activities, cognitive stimulation, and social connectedness (McClendon, Bass, Brennan, & McCarthy, 1998; Morris & Lundell, 2003; Mynatt, Rowan, Craighill, & Jacobs, 2001; "Spotlight Story: Interview with Eric Dishman", 2003). In the person-centered nursing home of the future, ubiquitous computing and embedded technology will emerge as assists in the environment by integrating computer technology into the physical structure and architecture, the furniture, and the social environment surrounding the resident. Infrared and radio frequency based elopement alarm systems can monitor many doors, elevators, and outdoor areas, accompanied with tracking systems that enable staff to locate residents who have left the facility (Technology for Long Term Care, 2006). Computer and communication-based Internet technology can provide support for addressing residents' psychosocial needs by connecting them to families, friends, and communities (Care For People With Dementia. Perspectives from Technology: A Research Planning Workshop for ETAC [Everyday Technologies for Alzheimer Care], 2004; "Digital home technologies for aging in place", 2004; Mynatt, Rowan, Craighill, & Jacobs, 2001). Two-way video connections adapted for the elder's level of physical and cognitive ability can provide social and cognitive stimulation by communicating with family and friends in other locations, internet chat sites, and accessing newspapers or information on topics ofinterest. Intelligent assis-

tive technology such as activity cueing, auto-minders, and televideo monitoring
will assist in wellness checking, provide information and decision-support, and assess changes in health or functional status (Brennan, Moore, & Smyth, 1995; Care For People With Dementia. Perspectives from Technology: A Research Planning Workshop for ETAC [Everyday Technologies for Alzheimer Care], 2004; Czaja & Rubert, 2002; Czaja, Sharit, Charness, Fisk, & Rogers, 2001; Morris & Lundell, 2003). The use of family portraits, ambient displays, and customized two-way video and computers offer methods to connect with others through the use of familiar devices (Dishman, Matthews, & Dunbar-Jacob, 2004; Mankoff et al., 2003; Morris & Lundell, 2003; Mynatt, Rowan, Craighill, & Jacobs, 2001; Nixon, 2006).

However, the majority of the applications and technology products are still in concept-for-test, prototype, and developmental stage. Further, major barriers to identifying and implementing technology in aging services include awareness, access, acceptance and adoption, and lack of regulatory standards and evaluation processes (U.S. Office of Technology and Policy, 2005; U.S. Office of Disability, Aging and Long-Term Care Policy, 2005). First, elders, their family and family caregivers, and healthcare providers often are unaware of the availability of emerging aging service-related technology products and lack information about where to find technologies. <Table 3> presents web resources and advocacy and interest groups that target improving awareness and knowledge in emerging technologies for elders. Second, making technology available for all elders with different cognitive, perceptual, and physical abilities is challenging. Universal design in technology products has been emphasized to improve accessibility of technologies. Third, healthcare providers may not see the importance of technology or be ready to accept and adopt technologies in delivering care. Factors that affect acceptance of aging-service technologies may include usefulness and usability, efficiency of care delivery, cost-effectiveness, and improvement of quality of life among elders. Healthcare providers are concerned about the technology's applicability to their situations/settings, the stability of the manufacturer, and the cost-effectiveness of the technology. They lack experience implementing and managing technological changes. Further, restrictions of financial and human resources prevent them from purchasing and implementing technologies. Finally, failure of the regulatory system to keep pace with technological advances stands in the way of implementing technologies. Regulatory agencies lack experience in evaluating technological applications in aging service. Currently, few regulatory standards and policies of reimbursement are associated with aging service technology.

< Table 3 > Resource Websites on Aging Technologies, Advocacy and Interests Groups

Center for Aging Services Technologies (CAST) Clearinghouse	Offers a user-friendly clearinghouse for current technology products, pilot projects, research and development, and emerging technologies. (http://www.agingtech.org/)
Technology for Long-Term Care	Provides information to professionals on available LTC technologies. (http://www.TechForLTC.org)
Aging and Disability Resource Centers (ADRCs), U.S. DHHS	Includes information about in-home services and nursing facility care (http://www.aga.gov/press/fact/pddf/fs_aging_disability.pdf)
Center for Independent Living (CIL)'s "Pathfinder for Services and Programs for Older Americans"	Includes a comprehensive reference manual on federal programs and legislation as well as a source of useful information and references on such as topics as assistive technology, home modification, transportation, and housing (http://rerc.ufl.edu/CIL/).
SPRY (Setting Priorities for Retirement Years) Foundation	Non-profit foundation for research and educational activities in the aging population. Develops consumer-oriented educational brochures and information on technology use (http://www.spry.org/about_spry/spry_portfolio.html). Carries out research and educational activities that emphasize planning and prevention-oriented strategies. Interested in enabling people to better access and understand new information by translating research findings into consumer-friendly language (http://www.spry.org/).
HIMSS and Center for Health Information and Decision Systems	The Health Information Technology (HIT) Dashboard provides a color-coded, easy-to-read visual interface that tracks over 500 state, federal, and private HIT initiatives related to electronic health records including LTC settings (http://www.hitdashboard.com/)
National Institute of Standards and Technology, Healthcare Standards Landscape	Publishes information on health information technology standards, organizations and related references. (http://hcsl.sdct.nist.gov:8080/hcsl/home.html)
Illinois Assistive Technology Program and Pennsylvania Assistive Technology Lending Library	Povides information on the availability of Assistive Technology (AT) services and programs for people with disabilities. (http://www.iltech.org/agingtechnology.asp and http://disabilities.temple.edu/programs/assistive/atlend/index.htm)
Intuitive Care Advisors (ICA)	Provides information about the newest development, distribution and adoption of home-based, technology-enabled healthcare products and services. (http://www.icareadvisors.com/index.shtml)

Gerontological Society of America (GSA)	Promotes the conduct of multi- and interdisciplinary research in aging and has a formal "Interest Group on Technology and Aging" that promotes and supports research and practice of applying technology to improve the quality of life for older persons (http://faculty.cua.edu/tran/gsa-tag/index.htm).
Alzheimer's Association	Organizes conferences and a workgroup on technology use in AD. Provides research grants of "Everyday Technologies for Alzheimer's Care (ETAC)" in partnership with Intel Corporation and Agilent (http://www.alz.org/).
AARP	Collaborates with numerous government, non-profit, and for-profit organizations on a wide range of matters related to aging including technology (http://www.aarp.org/)
National Association for Home Builders (NAHB), RemodelorsTM Council	Designs a "Life/Wise Home" with universal design principles and technologies (http://www.nahbrc.org/)

Conclusion

Growing evidence indicates that technology may transform aging services to be more efficient, effective, and user-friendly. Currently, aging service providers, government policy makers, manufacturers, and researchers in the U.S. put efforts on the development and use of technology that provides assessment and assistance of cognitive and functional abilities. If designed and implemented appropriately, technology potentially can be an important instrument to critically improve the quality of care for older population.

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