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Technology for Long-Term Care

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Introduction

By 2030 almost one in five Americans will be 65 years or older (National Institute of Health, 2006), straining the long term care system as well as the caregiving capacity of most American families. Nearly 60 percent of families will provide caregiving assistance (National Family Caregivers Association, 2000) and, with one in three households caring for a family member with cognitive impairment (Gaudet, 2005), needs for formal long-term care (LTC) will increase dramatically as the number of older persons who have cognitive or physical limitations soars. Most nursing home residents have both physical and cognitive impairments (80-90%) (Centers for Medicare & Medicaid Services, 2004; Maslow & Ory, 2001; Teresi, Morris, Mattis, & Reisberg, 2000) and nursing home costs, having grown from $18 billion in 1980 to nearly $100 billion in 2002, will continue to escalate.

The LTC industry is facing unprecedented challenges to address resident acuity while providing assistance in daily activities and personal care. Amid a nationwide shortage of nurses (U.S. Office of Disability, Aging and Long-Term Care Policy, 2005; Bee Capitol Bureau, 1997). and low wages associated with nursing assistant positions (Hospital and Healthcare Compensation Service, 2003).approximately 400,000 fewer nurses will provide care by 2020 (National Center for Health Workforce Analysis, 2002).

New approaches to services for older adults and institutional LTC are required to address these challenges. Service providers, government policy makers, manufacturers, and researchers assert that technology-based interventions have the potential to control these pressures, revolutionize the care for older persons, and improve the quality of life for residents in LTC. This article reviews the current state of aging technology, identifies areas of future research to determine efficacy to improve the quality of life of LTC residents, discusses barriers to implementating LTC technology, and presents a vision for technology use that radically reforms today's care practices.

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Current State of Aging Technology in Development

Government and academic research and business efforts to deploy technology in aging services are growing. 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 LTC Health Information Technology Summit suggests adopting health information technology will facilitate coordination, improve quality of care, and enhance efficiency in LTC and across the healthcare delivery continuum (American Health Information Management Association, 2005). Private initiatives including the Center for Aging Services Technology (CAST), developed under the auspices of the American Association of Homes and Services for the Aging, actively promote the role technology in supporting older adult care via professional and family care networks (CAST, 2003, 2005). The Department of Veterans Affairs (VA), the nation's largest network of aging-related services, uses technology-based home monitoring interventions for their older veteran population (Linkous, 2005).

Universities nationwide are organizing programs of study and research in gerontology and technology. The National Institute of Aging (NIA) establishedEdward Roybal Centers for Research to facilitatetranslation of basic science into practical outcomes including new technologies to benefit older adults. Rehabilitation Engineering Research Centers (RERCs) exist at 22 universities with approximately 25% addressing technology and aging research in the concept-for-test, prototype, and development phases. Table 1 presents selected research programs in U.S. based universities.

Technology companies (e.g., Intel, Microsoft) investigate a broad range of technology products and solutions to address cognitive and functional disabilities. Although specialized retail outlets and catalogs offer some products for older population, most technologies have not been customized or widely tested for their efficacy.

Areas for Future Research in Technology and Long-Term Care

Most current and emerging technologies for older population are in the concept-for-test, prototype, and development phases. There is a striking lack of evidence about the efficacy of the technologies in general, and in particular, on improving the quality of life for residents in LTC. Table 2 identifies the areas for future research in which current and emerging technologies ought to be tested for their effects of on improving the quality of life of LRC residents.

The current and emerging technologies have mostly been used for older adults in community or acute care setting. Thus, little is known about the potential benefits of the technologies in residential care settings. Technologies that are relevant for LTC may include products and services that enable persons to perform tasks or functions in activities of daily life, promote a sense of control and dignity, and improve the quality of life in an institutionalized setting including nursing homes and assisted living. The technology products can be worn ("on"), embedded ("in"), and placed in the person's environment ("around") (Barrett, Holmes, & McAulay, 2003). Optimally they are unobtrusive, preventive, personalized, and remote. All three types of products may connect to each other and work across an expanded healthcare network. LTC-related technology should support daily life activities and enrich resident quality of life addressing safety (falls, wandering) to self-care activities (bathing, medication, eating, mobility, sleeping) to communication (social interaction and connection) to entertainment (recreation, leisure). Optimally, a technology products and services should support facility staff and family (e.g., electronic medical records and recording devices, or distance connectivity to enhance family caregiving). Therefore, future research to guide the development and use of technology must include assessing while helping, adapting assistance to variability in cognitive and functional abilities, catalyzing instead of replacing social interactions, and using familiar interfaces (Morris & Lundell, 2003). Further, it is important to examine the efficacy of the technologies on assisting residents and nursing home staffs 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; Dishman, 2004).

One of the greatest potential benefits from current and emerging technologies would be a possibility to provide a new person-centered environment in LTC settings ("Computer-based technology and caregiving for older adults. Special National Conference Report," 2003). Person-centered LTC technology allows high-tech options where residents are primary consumers of products used to improve their function and quality of life. High-tech approaches undertake calm technology which recedes into the background of residents' lives (Weiser, 1996), Some of high-tech options may include wireless broadband, biosensors, activity sensors, information fusion systems, ambient displays and actuator networks, and remote community and collaboration (Dishman, Matthews, & Dunbar-Jacob, 2004).

In the person-centered nursing home of the future, ubiquitous computing and embedded technology may assist 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 (Polisher Research Institute,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 older adult'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 of interest. Intelligent assistive technology such as activity cueing, autominders, 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 et al., 2001; Nixon, 2006). However, the efficacy of the technologies in LTC is not known because these types of technologies are recently developed or still in development. Thus, this article focused on identifying areas for research, providing detailed examples of potential technology use in LTC, and proposing the efficacy testing of the technologies in future research. In future research, researchers need not only to test the efficacy of the technologies but also to examine the potential detriments to introduction and use of technologies in LTC. Further, it is critical that future research explores residents' perception about high tech LTC environment and examines high touch humanistic care from nursing staff in LTC.

Barriers to the Implementation of LTC Technologies

Major barriers to identifying and implementing technology in LTC include awareness, access, acceptance and adoption, and lack of regulatory standards, reimbursement, and evaluation processes (U.S. Office of Technology and Policy, 2005; U.S. Office of Disability, Aging and Long-Term Care Policy, 2005). First, older adults, their family and family caregivers, and LTC providers often are unaware of the availability of emerging LTC-related technology products and lack information about where to find technologies. Table 3 presents the related resource websites for technologies in aging and includes the advocacy and interest groups that promote awareness and knowledge in emerging technologies for older adults. Second, making technology available for all older adults with different cognitive, perceptual, and physical abilities in LTC is challenging. Universal design in technology products has been emphasized to improve accessibility of technologies. Third, LTC industries may not see the importance of technology or be ready to accept and adopt technologies in delivering care. Factors that affect acceptance of LTC technologies may include usefulness and usability, efficiency of care delivery, cost-effectiveness, and improvement of quality of life among residents. LTC providers are concerned about the technology’s applicability to their situations/settings, the stability of the manufacturer, and the cost-effectiveness of the technology and whether it will integrate and operate with other technologies (interoperability). They lack experience implementing and managing technological changes. Further, restrictions of financial and human resources prevent them from purchasing and implementing residential LTC 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 LTC. Currently, few regulatory standards and policies of reimbursement are associated with LTC technology.

The report from the U.S. Office of Disability, Aging and Long-Term Care Policy (2005) suggests that the educational and exploratory strategies to address the barriers require: improving knowledge and awareness about technologies in residential LTC settings, developing and implementing cost-effective technological innovations in residential LTC settings, reducing regulatory barriers to innovation, developing industry standards for technologies salient to the LTC setting, and educating LTC providers about implementing and managing technological change. In regards to interoperability issues, the Continua alliance recently issued its first set of industry standards that technology developers must meet in order to place the Continua seal of approval on their products, thereby assuring purchasers about compatibility.

A Preferred Future and New Vision

What is the future for technology usage in nursing homes? Given the previous review of the state of the art in today’s technologies and prototypes, we suggest that these developments are becoming near-term options. A plethora of opportunities exist to integrate a wide range of new technologies into LTC within a decade. At present, a handful of nursing homes are serving as test beds for specific technology interventions. In the future, the nursing home will not be limited to retrofitting single focus technology into their facilities for testing but will integrate multiple technologies incorporated into new buildings or through major renovations (Mahoney, 2009).

Why will there be such development efforts? Primarily to attract baby boomers as residents, to survive competition from the increasing number of LTC housing options, to maintain financial viability amid regulatory compliance, and to reduce liability given the escalating shortage of nursing staff, traditional institutional LTC must change. Technology provides the solution not only to address the labor, regulatory, and competition issues but also improve the quality of care for residents. Savvy consumers will be comparing facilities' technologies thereby generating a competitive drive among facility administrators to upgrade their services.

Can they afford new technology? Used prudently, technologies will offer the possibility of doing more services with less manpower and administrative costs. While we are not suggesting that technology substitute for hands-on care, we do imply that hands that have done paperwork and performed non-skilled tasks can be re-deployed to direct care. Efficiencies gained in better organizational activities and deployment of skilled workers will translate into cost savings. And, as technologies on average rapidly drop in price every 18 months, over a short period of time they become affordable thereby increasing access.

How do we overcome staff resistance to technology? Technology must serve a useful purpose, productively relieve the staff from non-essential tasks, and have a strong potential to increase staff satisfaction and morale. As organizational change theory predicts, not only will there be staff wedded to tradition but also champions who must be found, cultivated, and supported to direct the change process in a positive manner. We will need these people to provide input to the technology design team so that products are chosen that can fit and be molded to their agency's needs. Prior research suggests the key agents to change practices in nursing homes are the administrator who legitimizes and advocates the change with a director of nursing who directs the process through nurse champions who implement it on each shift (Mahoney, 1995). This team should be involved in the technology planning, design, and usability testing for their organization. Finally, federal and state regulations drive LTC practices as the governmental payer and aims to ensure resident safety and financial accountability. While these aims appear logical and simple, trying to achieve them in an industry with wide variability in residential administrative practices has been elusive. In our future world, the aims will be reached through technology. Governmental regulations will favor those who adopt and use electronic records in LTC. Nursing home surveyors will no longer have to visit every home to ensure quality but receive sentinel alert reports from nursing home systems that automatically identify facility criteria lapses or unrectified deficiencies. Nursing home administrators will receive notification ahead of time to address deficiencies before they are posted publicly. Staff time and efforts will be recorded via signals from their badges to the nursing home's computer thereby eliminating narrative documentation. Smart appliances will send reports on their temperature and functioning for environmental and kitchen safety. Overall the imbedded technology in the everyday environment will be the recorder and documenter of many of today's tasks. Most importantly, it will uniquely add a critical missing quality oversight piece that is "real time" monitoring with pro-active sentinel alerts to negative patterns within and across facilities that is unfeasible today.

Once "unfrozen" from current negative stereotypes of institutional warehousing of residents who submit to daily schedules based on institutional routines, with staff focused on paperwork and administrative regulations, what would daily life be like? Foremost, residents would drive care through their needs, wants, and preferences. Technology would enable individualized care tailored to the resident as shown in the following example.

> Mr. Jones likes to watch late night TV until 2am and then sleep until 10am. Bed sensors indicated two episodes of urinary leakage that triggered an automated disposable bed pad change that left him undisturbed, asleep, and dry. Upon arising, he prefers to shave first, then have breakfast, take his pills, read the paper, wash, and get dressed. Robere is there to help him with these tasks. Mr. Jones makes a video visit with his daughter at noon and changes the channel to start his personalized therapeutic exercise program to strengthen his muscle tone. Robere

> accompanies him when he ambulates as directed on the walking path and guides him back to his room. Mr. Jones has his lunch at 3pm. He plays games with Robere and takes his pills from him at 5pm. His nurse practitioner checks in with him on the video screen and reviews his vital signs and metabolic readings. She notes from the sensor reports that his walking pattern and distance have deteriorated, and he reports that his hip pain is worsening. She adjusts his medications to decrease the discomfort from arthritis and the changes are automatically sent to the dispensing pharmacy, Robere, and the resident record. Mr. Jones prefers to eat late, sometime after 8pm, which is no problem because Robere can prepare dinner whenever requested. Robere also helps Mr. Jones to get ready for bed around 11p,m. and offers the new arthritis medication .so it will be effective by bedtime to reduce night time awakenings due to joint discomfort and hip pain when he arises.

Robere works 24/7, is culturally competent, can communicate in any resident's preferred language, and "knows" their usual patterns of behaviors and personal care preferences. How can that be? Robere is a robotic aide. In fact, one prototype to help nurses lift and move patients is in prototype now (Mahoney, 2009) while another is in the battlefield helping to remove wounded soldiers in the field under enemy fire (Vecna, 2006). In our futuristic scenario, we will name it RoBear, a miniaturized personal robot aide, always ready, never tired or off duty with affective computing ability. That is it can respond to emotional expressions and convey features on its face and in its intonations that range from happiness to sympathy. RoBear's eyes also transmit video, its belly is a screen that displays two-way communication and its hands sense and transmit physiologic reports. Residents can now decrease their social isolation by having virtual visits via RoBear or their two-way communication screen in their room with their friends and family any time any day in between onsite visits. This video also can transmit health care data and send images to health care providers. RoBear integrates and processes all the signals sent per assigned resident and emits the sentinel alerts. "RoBears" will be the 24/7 companion of the most disturbed residents with AD, learning their patterns of behaviors, what triggers their upsets, and adjusting the environment to become a soothing place for them rather than a source of stress. For the physically impaired, "RoBears" will safely lift and transport them via their imbedded seat. If completely dependent and bedridden, "RoBears" will gently lift and move residents every two hours or more frequently if desired thereby reducing the incidence of bedsores. For quadriplegics, "RoBears" will respond to voice commands and provide a new means of independence and preservation of personal dignity. They also will take diagnostic x-rays and transmit digital pictures of skin changes or wounds to specialists, thereby decreasing uncomfortable, disorientating, and costly ambulance rides. No longer will it be problematic to have physicians respond to telephone calls from a nursing home or make a visit on site. Virtual visits will be commonplace, and all data posted simultaneously to authorized information accounts. Research has documented that frail spouses often travel daily to maintain vigilance over their institutionalized loved ones with AD resulting in high caregiver stress (Mahoney, 2003a,b). As authorized account holders, they will gain access to daily updates and maintain interactive video vigilance without risking travel and falling in adverse weather conditions. While the practical aspects of building such wholistic robotic assistance remains quite formable, research to date has demonstrated that remote monitoring of older adults is acceptable and reduces caregiver anxiety when they cannot be on site (Mahoney 2004).

What will the nursing staff be doing if not charting and administering medications? In our future world, they will specialize in overseeing and ensuring the residents' quality of care. Nurses will provide the high touch humanistic aspect of care to offset the possibility of a high tech atmosphere without any warmth or sensitivity. They will have the time and the charge to make "touch" rounds where they will hold a resident's hands or give a massage while they listen to their concerns and assess the match between their needs and the present plan of care. They will easily re-program the technology or adapt it to fit the resident's needs and wants from the bedside. The nurses will direct the use of technologies to enhance resident/family/provider communications. Based on their assessment and review of video logs, they will prescribe the diversionary and therapeutic activity technologies that are best suited for cognitively impaired residents who sundown, continually exit seek, or exhibit AD related acting out behaviors. They will assess the sentinel alerts for reliability and validity and initiate remedial actions when warranted. The nurse will leverage her professional assessment and management skills making this position more attractive to recruit new nurses. And, because of Robear's lifting abilities, back injuries will be eliminated among the nursing staff, thereby helping to not only retain older staff but also reduce worker's compensation claims.

Overall, technology-if well designed and interoperable-carries the potential to be the powerful integrator of health information across all sectors in the health care industry (Mahoney 2000, 2008). It can address the notorious gaps in medical record information, medications, therapeutics, and discharge planning that occur for residents who become patients in acute care and then cycle through rehabilitation, LTC, and around again. It offers the potential means to transform inefficient patterns of care and documentation into support for professional caregivers and providers to improve the quality of care, tailor it to an individual's needs, improve consumer satisfaction, and reduce health care costs. To reach this potential users and purchasers of technology need to demand products that fit their needs, provides practical solutions that integrates seamlessly into the environment without disrupting normal activities. There remains a critical and immediate need to study technology prototypes to discern potential problems in design, usability, and functioning in non-laboratory real world settings. Evaluation of new technologies does not match expectations for traditional NIH research grant funding (Alwan & Mahoney 2006). Yet commercial sponsorship of evaluative studies can create a financial bias to report positive findings. Confirmatory research by non-affiliated external evaluators such as academic researchers is needed. Once a given technology has matured and is deployed enough to enable large scale comparative studies, future research is warranted to examine it's efficacy, including cost and quality of life outcomes.

Conclusion

The preferred future for older adult-centered care in nursing expands the current model of computer technology and other emerging technology from a conscious presence to becoming embedded in the environment to assist in 'daily life' and 'enrichment.' If designed and implemented appropriately, technology potentially can be an important instrument to critically improve the quality of care for this population.

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Table 1

Selected Research Programs in U.S.-based University Research Centers

Research Centers	Areas of research
Massachusetts Institute of Technology (MIT) AgeLab	Eelectronic toy pets for medication taking, bio-sensors to monitor health, Alzheimer's disease and wandering safe return (http://web.mit.edu/agelab)
Georgia Institute of Technology	The Aware Home Research Initiative on social communication, memory aids, and everyday home assistants (http://www-static.cc.gatech.edu/fce/ahri/projects/index.html)
University of Florida RERC on Technology for Successful Aging	The Gator-Tech Smart House program with smart technologies. (http://www.icta.ufl.edu/gatortech/index2.html)
University of Colorado RERC for Advancing Cognitive Technologies	Assistive technology for people with cognitive disabilities. (http://www.colemaninstitute.org/about.php)
Consortium of University of Pittsburgh, University of Michigan, National Aeromautics and Space Administration Johnson Space Center, and AT Sciences	Memory aids, activity assistant, cognitive orthotics, and robotics. (http://www-2.cs.cmu.edu/~nursebot)
The Oregon Roybal Center for Aging, Technology, Education & Community Health	Intelligent pill box, home sensors and tracking devices, intelligent walkers and canes (http://www.ohsu.edu/alzheimers/roybal/)
The Medical Automation Research Center at University of Virginia	Automation and robotic solutions for in-home monitoring system and sleep monitoring system, intelligent automated assistive walking device (http://marc.med.virginia.edu/projects.html)
University of Washington	Assisted cognition and system for human activity recognition and prediction (http://www.cs.washington.edu/assistcog/)
The Center for Future Health at University of Rochester	Medication assistance and automated health Assessment" systems (http://www.futurehealth.rochester.edu)
Center for Research & Education on Aging & Technology Enhancement (CREATE)	Research on human interaction with technology. (http://www.med.miami.edu/psychiatry/create.html)

Table 2

Areas for efficacy testing of potential LTC technology and Examples

Areas	Technology	Examples of potential technology use
SAFETY/PREVENTION/DETECTION		
■ Falls	Gait and motion sensors, Global Positioning System (GPS) devices, ambient displays, and actuator networks	Sensors installed in the facility to monitor gaits and motions of residents. *Example: Activity sensors are placed in a wall or within each living space in the facility. The sensors track the elder's gait, stability, and movement pattern and identify pattern changes that reflect an increased risk for falls. They also detect any fall and alert staff immediately for intervention (e.g., in field testing: "In-Home Monitoring System" by University of Virginia).* A wireless pendant or wristband with a personal help button *Example: Pushing the button alerts staff to send help. (e.g., in market: A "personal help button" by ADT security services)*
■ Wandering	Wireless motion sensors and a GPS location system	Location, object, and person tracking around the facility. *Example: Sensors will send alert to staff if elders with AD exit doors and wander out of facility (e.g., in development: "Lifeline" by University of Colorado).* *Example: A resident at risk for wandering may wear small necklaces, key-chains, or other familiar devices embedded with GPS devices. These can be attached to clothing and other items to track and locate a resident who has left the facility. (e.g., in market: "Wheels of Zeus" by Apple Computer co-founder Steve Wozeniak)*
■ Pressure Ulcer	Biosensors	Sensors installed on personal items *Example: Sensors are attached to a pair of socks and detect swelling in a resident's feet and relay the change to staff (e.g., in concept proposal: CAST, 2005).* *Skin images are sent for dermatological analysis.* *Example: Sensor attached to a mattress monitor pressure distribution, detect any skin change of a resident, and alert staff (e.g. ,in development: "Smart Bed" by University of Florida, or Remote teledermatology in home treatment study at Partners Telemedicine)*
■ Wellness monitoring	Biosensors, behavioral sensors, and bodily diagnostics Information fusion and inference engines	Real-time, routine chemical analysis *Example: The real-time biosensors track routine blood chemistry analysis and monitor any changes. Sensors in the toilet also do chemical analysis and track any changes.* Functional and cognitive ability measurement and assessment/personal baselines and alerts to meaningful deviations *Example: Physiological and behavioral changes are monitored through sensors and assessed for depression, cognitive decline, and dementia. The data supplied by sensors will be evaluated for changes over time, thus ideally enabling trend analysis and assessment of residents' physiological, cognitive, psychosocial wellbeing. (e.g., in development of a basic room and staff monitoring systems: "digital danskin" by MIT, or "Automated Care System (ACS)" at the Oatfield Estates assisted living facility, Milwaukee, Oregon)*
ACTIVITIES OF DAILY LIFE		
■ Bathing	Sensors, information transfer, decision guidance systems	Remodeling and redesigning bath environment Monitoring and heath promotion with sensors *Example: Handrails in the bathtub not only prevent residents from a slip or fall but also check vital signs and skin status. Sensors in the tub measure the water temperature and self regulate the inflow water temperature (e.g., in development: "Smart Bathtub" by the University of Florida).* *Example: A sensor in a toothbrush analyzes saliva and identifies any vitamin, mineral or enzyme deficiencies,*

Areas	Technology	Examples of potential technology use
		along with a resident's current blood sugar levels. The information is sent to staff for possible adjustment of dosages of vitamins and prescription drugs (e.g., in concept proposal: CAST, 2005).
▪ Eating	Sensors, wireless information transfer, and decision guidance systems	Sensors for assessment, monitoring and detection. Information transfer and decision guidance systems for evaluation and planning *Example: The bathroom scale detects weight changes of a resident and sends the information to rehabilitation equipment such as a treadmill, which customizes his/her weekly workout program. A menu-planning program simultaneously increases or decreases the daily calories and fat in a customized daily menu plan and sends the information to the kitchen. Weight and oral intake information is sent directly to the electronic medical record (e.g. in concept proposal: CAST, 2005).*
▪ Mobility	Sensors, robotics, and mechanical engineering	Assisted mobility *Example: Ceiling mounted lifts are activated by a resident pushing a wall button. They move from room to room and attach to multiple overhead track systems to lift, transfer, and transport residents with physical limitations to and from a bed, toilet, bath, chair, and the floor. (e.g., in development: "Lifting and Transferring" at "Technology for Long-Term Care")* *Example: An intelligent walker or autonomous robotic wheelchair with adaptive guidance may tell a resident with low vision directions to avoid any obstacles, allow him/her to power across gravel, grass, and other uneven terrain, and hold a conversation on the move (e.g., in market: "iBot Mobility System" by Johnson & Johnson, Inc.).*
▪ Sleeping	Wireless sensors	Information of sleep behaviors *Example: A mattress pad in the bed can detect the sleeping position of a resident, the minutes of nighttime sleep, the number of awakening, the count of breaths per minute, % of time in bed, and the level of room light. The information is sent to staff for monitoring. (e.g., in field test: "Sleep-Monitoring System" by University of Virginia).* *Example: A care system for use in the homes of people with cognitive disabilities such as Alzheimer's disease includes security system control pad, a wireless receiver, motion sensors, door opening sensors, and a bed occupancy sensor. No alarms go off after the client goes to bed. This allows caregivers to move around in the home without triggering the alarm. The system automatically activates once the client rises (e.g., in development: "CareWatch" system by Rowe, Lane, & Phipps 2007).*
▪ Medication	Biosensors and medication dispensers with motion sensor	Targeted drug delivery and effects analysis. *Example: The real-time, non-intrusive biosensors will track medication dosage and frequency, fluid and solid nutritional intake, which could be modified based on the analysis. Then, the effects on blood chemistry could be quickly and easily assessed.* *Example: The amount, frequency, type of medications are tracked and monitored through sensors on automated medication dispensers. Automated medication dispensers improve safety and reduce errors. These dispensers are equipped with audio and visual reminders and personal emergency response systems. (e.g., in development: "MedTracker" by Oregon Health and Science University, or "Chester the Talking Pill" by University of Rochester)*
▪ ADL helper	Artificial intelligence and robotic engineering	Reminding and assisting in activities of daily living *Example. A robotic aids residents with dementia by reminding them about activities of daily living, taking vital signs, and fetching items (: e.g., in development: a "nursebot" named Pearl)*

Areas	Technology	Examples of potential technology use
	Adaptive, distributed interfaces	Personalized interactive experience for daily activities *Example: Residents use their desktop, or overbed table, as the screen for selecting meals, adjusting their personal schedule for the day, and connecting with others.*
COGNITION		
	Ambient displays and actuator networks	Assistive cognition and mental fitness *Example: For the elder with cognitive impairment, a digital portrait will display reminders such as time, date, and faces and names of family members. The auto reminders and prompts are customized to individual specifications, employing strategies to retain and stimulate cognitive reserve. The elder can call up virtual reels from a personal library of family portraits, videos of past pictures or family events of significance, movies, documentaries, books, and plays for viewing (e.g., in development: "Smart Mirror" by University of Florida).* *Adaptive cognitive orthotics*
	Cognitive orthosis technology	*Example: Autoreminder, an intelligent cognitive orthotic, provides adaptive reminders to residents with dementia based on their evolving needs and actions (e.g., in development: "SHARP" by University of Washington, or "MAPS" by University of Colorado).*
SOCIAL CONNECTIVITY/ COMMUNICATION		
	Wireless broadband, remote community and collaboration	Multiple modes and media for communicating across distances *Example: Wireless broadband enables the elder to engage in contacts both within and outside the institutional environment, virtually connecting with family, friends, and professional colleagues around the globe.* *Ways of representing and feeling "presence" at lonely times* *Example: Using a digital monitor projected on the wall and voice commands or other prompts, elders will virtually connect via videoconferencing with friends, family, and professional/hobby colleagues at a distance.* *Example: The computer face will light up when an internet friend or family member has checked in or is available. Somewhat like the current 'instant messaging' technique, the elder is alerted through a visual or auditory notice that 'others' are present and can be prompted.* *Rich and multiple streams of information delivery* *Example: Elders may choose to have health information sent to family members or to other professional providers, including independently-hired geriatric case managers, who advocate on their behalf (e.g., in development: "Digital Family Portrait" and "Dude's Magic Box" by Georgia Institute of Technology).*
RECREATIONAL/ SPIRITUAL ACTIVITIES		
■ Recreation	Computer technology and virtual reality systems	Desktop, laptop, handheld computers Simulated room/environment created by a virtual reality system *Example: Residents use computers to watch a big-screen display of scenery pictures with music, create a greeting card, or play computer games for enjoyment and mental stimulation.* *Example: Residents with mobility limitations may walk around a virtual garden or bike trail created by a virtual reality system (e.g., in market: "Simcycle", a simulated bike exercise program by It's Never 2 Late, Inc.).* *Example: Residents use publishing software to write their life stories and publish them on the Internet. (e.g., in market: Silver Stringers).*
■ Companion-ship	Robotics	Artificial intelligence pets for support that may help decrease feelings of isolation or depression *Example: A "smart" cat (robotics) may calm an agitated Alzheimer's patient by purring at the bedside or responding with movement when held and stroked. (e.g., in market: AIBO, a robotic dog, by Sony*

Areas	Technology	Examples of potential technology use
		Corporation).
	Computer technology	*Example: Residents use computers to visit with pastors of their churches via videoconferencing.*
STAFF AND FAMILY SUPPORT		
■ Resident	Sensors and monitoring robotics	Facility driven by technology *Example: Staff monitors the medical condition of the residents with a robot that is equipped with sensors and is linked to a large screen in the nurse's station (e.g., in development: "Tama, a robot teddy," developed by Matsushita Electric).*
■ Electronic health records	Information Technology	Central repository for personal and professional health information Tools for easy visualization of long-term trends and care evaluation and planning *Example: The personal and longitudinal health records across settings from home to hospital to LTC facility can allow staff to assess comprehensive health information about an individual's biobehavioral patterns and to evaluate and plan for care.*
Family involvement	Wireless broadband Networking	Mobile communication and computing devices (MCCDs) Internet access between family member and LTC facilities *Example: LTC facilities open access to data reflecting the daily routine of their family members. This process allows the family member greater input and involvement in their loved ones' care.* *Example: Family members join virtual caregiving networks, exchange information about publicly and privately provided health care services, and receive formal or informal support.*
	Personal health informatics	Central repository for personal and professional health information Tools for easy visualization of long-term trends *Example: Personal health information is projected to designated family caregivers, independently hired personal care managers, or friends who are serving as advocates. Information is translated into a language and format understandable to the layperson. When needed, best evidence care protocols may be included with each projection of information.*

Table 3

Related Resource Websites for Technologies in Aging

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/)
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)
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/).
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/)
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/).
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).
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/)
Illinois Assistive Technology programs 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)
National Association for Home Builders (NAHB), Remodelors™ Council	Designs a "Life/Wise Home" with universal design principles and technologies (http://www.nahbrc.org/)
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)
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/)
Technology for Long-Term Care	Provides information to professionals on available LTC technologies. (http://www.TechForLTC.org)