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Introduction and Themes of the Workshop[1]

The Institute of Medicine (IOM) and the National Research Council (NRC) have had prominent roles in discussions of aging, disability, and technology for decades. In 1978, *Aging and Medical Education* (IOM, 1978) raised national awareness of the challenges to physicians posed by the aging of the U.S. population. Thirty years later, *Retooling for an Aging America* (IOM, 2008) highlighted concerns for the entire health care workforce in view of the aging of the population, including the role of technology in caring for older populations. The 1988 report *The Aging Population in the 21st Century* (NRC, 1988) examined social, economic, and demographic changes among older adults, as well as many health-related topics: health promotion and disease prevention; quality of life; health care system financing and use; and the quality of care—especially long-term care. In 1991, the landmark report *Disability in America* (IOM, 1991) laid out a national agenda to prevent disability and improve the lives of people with disabling conditions. The 1997 report *Enabling America: Assessing the Role of Rehabilitation Science and Engineering* (IOM, 1997) examined the knowledge base of rehabilitation science and engineering and proposed ways to translate scientific findings into interventions that produce better health. And the 2007 report *The Future of Disability in America* (IOM, 2007, p.10) examined progress made since the earlier reports and looked at continuing barriers that limit the independence, productivity, and participation in community life of people with disabilities, concluding that "disability is not an unavoidable consequence of injury and chronic disease but is substantially affected by the actions that society takes."

All these reports were produced by committees appointed in accordance with guidelines of the National Academies and met multiples times to compile and review evidence, reach consensus on conclusions and recommendations, draft a report of the committee, and then modify that draft report in response to comments from outside reviewers. The IOM and NRC have also held several workshops related to aging, disability, and technology and published summary reports, such as *Technology for Adaptive Aging* (NRC, 2004) and *Grand Challenges of Our Aging Society* (NRC, 2010). The IOM and NRC also convene groups that take a different approach to issues of pressing national and international importance. Often known as forums or roundtables, these groups meet regularly to foster dialogue and confront issues of mutual interest and concern among a broad range of stakeholders. They can convene workshops, initiate cooperative projects among members, commission independently authored articles, and generate ideas for independent consensus studies.

In 2012 the IOM and NRC joined together to establish the Forum on Aging, Disability, and Independence to provide a neutral venue for broad-ranging discussions among the many

[1] The planning committee's role was limited to planning the workshop, and the workshop summary has been prepared by the workshop rapporteurs as a factual summary of what occurred at the workshop. Statements, recommendations, and opinions expressed are those of individual presenters and participants and are not necessarily endorsed or verified by the IOM or the NRC, and they should not be construed as reflecting any group consensus.

stakeholders involved with aging and disability.[2] The goals of the forum are to highlight areas in which the coordination of the aging and disability networks is strong, examine the challenges involved in aligning the aging and disability networks, explore new approaches for resolving problem areas, elevate the visibility and broaden the perspectives of stakeholders, and set the stage for future policy actions. Forum sponsors and members include federal agencies, health professional associations, private sector businesses, academics, and consumers.

WORKSHOP STATEMENT OF TASK

The summary of the 1991 report *Disability in America* (IOM, 1991) stated the following:

> Disability is the expression of a physical or mental limitation in a social context—the gap between a person's capabilities and the demands of the environment. People with such functional limitations are not inherently disabled, that is, incapable of carrying out their personal, familial, and social responsibilities. It is the interaction of their physical or mental limitations with social and environmental factors that determines whether they have a disability. Most disability is thus preventable, which will not only significantly improve the quality of life for millions of Americans but also could save many billions of dollars in costs resulting from dependence, lost productivity, and medical care.

An increasingly important aspect of the "social and environmental factors" that determine whether an individual has a disability is the technology to which that person has access. Technology-driven assistive and adaptive products have improved functioning and quality of life for people of all ages. Furthermore, the potential of technology remains immense to increase the number of disability-free years in the average life span.

To explore this potential, the Forum on Aging, Disability, and Independence, as its first formal public activity, held a workshop in Washington, DC, on December 19, 2012, titled "Fostering Independence, Participation, and Healthy Aging through Technology." More than 100 people attended the workshop, and more than 100 remote participants registered to watch the workshop on a simultaneous webcast.[3] Box 1-1 lists the workshop statement of task.

Overall, workshop speakers were asked to meet the following objectives:

- Focus on adults who by virtue of an inherited/congenital condition, accident, or disease(s) become impaired in their ability to be as independent as possible as they age.
- Provide an overview on how the independence, community integration, and well-being of these individuals can be improved through access to and increased use of technology.
- Examine existing and emerging technologies, with a focus on technologies most likely to be employed.
- Discuss barriers to deployment and adoption of technologies and reasons for abandonment of technologies already in use.

[2] Forum website is www.iom.edu/ADIForum.
[3] The archived webcast is http://www.iom.edu/Activities/Aging/AgingDisabilityForum/2012-DEC-19.aspx.

BOX 1-1
Workshop Statement of Task

An ad hoc planning committee will plan a 1-day public workshop to examine the ways in which technology can foster independence and healthy aging among working-age individuals with disabilities and among individuals who are developing disabilities as they age. The workshop will feature invited presentations and discussions that will

- provide an overview on how the independence, community integration, and well-being of older adults and individuals with disabilities can be improved through the increased use of and access to technology;
- examine existing and emerging technologies, with a focus on technologies most likely to be employed ("straddling promise and reality"); and
- discuss barriers to deployment and adoption (and abandonment) of technologies.

The planning committee will develop the agenda for the workshop, select and invite speakers and discussants, commission any papers in advance of the workshop, and moderate or identify moderators for the discussions. A single individually authored summary of the workshop will be prepared by a designated rapporteur based on the information gathered and the discussions held during the workshop.

ORGANIZATION OF THE WORKSHOP SUMMARY

This summary of the workshop describes the presentations of the speakers and compiles the comments made by workshop participants and speakers in the rich discussions that followed the talks. Chapter 2 examines several past and ongoing initiatives as examples of the tremendous potential that technology has to restore functional capacity and avert deterioration in functioning. Chapter 3 focuses more specifically on the use of technologies to promote activities of daily living and independence. Chapter 4 looks at how technologies can promote community integration and participation in the context of community design, and Chapter 5 examines community integration and participation from the perspective of social connectedness. Chapter 6 investigates how technologies can help manage and promote health. Chapter 7 summarizes comments made during the discussion sessions as a way of revisiting the major issues raised at the workshop. The workshop agenda and biographical sketches of the speakers appear in Appendixes A and B, respectively.

THEMES OF THE WORKSHOP

Over the course of the workshop, speakers raised several prominent ideas that structured both their presentations and the subsequent discussions. These ideas are presented here as an introduction to the themes of the workshop, with the speaker who discussed the idea identified in parentheses. These themes should not be seen as conclusions of the workshop as a whole or as recommendations of the workshop participants; the Forum on Aging, Disability, and Independence; or the IOM or NRC.

The Challenge

- High technology is not necessarily the answer to every problem. Relatively simple technologies are needed to solve common but extremely complex problems, such as going to the bathroom or getting out of bed. (Fernie)
- Many excellent technologies are not widely used for a variety for reasons, including inadequate reimbursement, insufficient funding for translational research and technology, and a lack of collaboration and training among technology developers and providers. (Cooper)
- Because families are smaller today than in the past, fewer children are present to care for parents, and many of them live farther away and have jobs. (Coughlin)
- Until technologies that are obvious, easy, relatively affordable, and sensible are widely available, the market will have failed the people who could benefit from those devices. (Coughlin)
- Interoperability and interconnectivity of different technologies, such as between health care systems and devices, are necessary to facilitate the exchange of information and to ensure the continuity of information and care especially for individuals who receive care from, or transition between, multiple care provider organizations. (Alwan)

The Promise

- The convergence of aging and disability has created an economic and political opportunity to rewrite the narrative of aging. (Coughlin)
- Technology can both prevent disabilities and provide people who have limitations with as much mobility and freedom as possible. (Fernie)
- Technologies can make life possible for individuals with diseases that in the past would have ended their lives. (Saling)
- Universal design, in which all homes include the features needed to accommodate limitations, can benefit everyone who lives in or visits those homes. (Cooper)
- More accessible and useful transportation can meet the needs of people with disabilities and could have widespread benefits for all travelers. (Yousuf)
- Workplace accommodations are about more than the performance of work tasks; they also can create participation in the workplace that leads to a sense of belonging, inclusion, and recognition that work is adding value to the organization. (Sanford)
- Maintaining accessibility across all Web environments is essential for healthy aging, whether someone has a disability or not. (Brewer)
- The Web will not be usable and available to all people without devoting effort to accessibility initiatives that shape the shared public infrastructure. (Lewis)
- Monitoring health conditions among older people using newer methods of biomonitoring can improve health but still faces technological and cultural barriers. (Agostini)
- Technological advances, motivational influences on behavior, and cultural change among individuals and in communities are enhancing the capacity of rehabilitation science to forestall the onset of disability. (Winstein)
- When automated interactions between the health care system and patients more closely emulate human-to-human interaction, they can better promote accessibility, engagement, adherence, and retention. (Bickmore)

- The best way to develop successful technologies is to have individuals with cognitive and developmental disabilities using the technology in their homes and communities. This will help to figure out what is most effective and to determine where changes are needed. (Wellems)
- Strategic partnership among acute, postacute, and long-term services and supports could make the widespread adoption of technology a reality. (Alwan)

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The Promise of Technology

As suggested by the workshop title, technology has tremendous potential to foster independence, participation, and health as people age. The first four speakers at the workshop provided perspectives on this potential from widely varying vantage points. Joseph Coughlin, director of the Massachusetts Institute of Technology AgeLab, examined some of the reason why the many excellent technologies developed in laboratories are not more widely used. Geoff Fernie, professor at the University of Toronto and director of research at the Toronto Rehabilitation Institute–University Health Network, presented specific examples where technology can prevent disabilities and overcome limitations. Majd Alwan, executive director of the LeadingAge Center for Aging Services Technologies, outlined a program aimed at developing, validating, evaluating, and adopting transformative technologies. And Steve Saling, who has amyotrophic lateral sclerosis (ALS) and communicates through a silver dot on his glasses, described the award-winning homes he has helped design for ALS patients. Saling in particular demonstrated that even the most severe physical limitations need not result in disability.

GETTING TECHNOLOGIES OUT OF THE LABORATORY

Joseph Coughlin, Ph.D.
Massachusetts Institute of Technology AgeLab

The baby boomers have always been a vocal as well as a large cohort. As they retire, they are more likely than previous generations to demand a high quality of life as they age—creating a policy and political dilemma that is only going to escalate. This is, he said, becoming a driver of politics and of the market.

Older Americans are living longer today than their grandparents' and great-grandparents' generations, but they are also likely to have chronic conditions that will lead to disability. According to Coughlin, of the total U.S. population of about 310 million people, 110 million have a chronic disease, 60 million have two chronic diseases, and 20 million have five or more chronic conditions.[1] This convergence of aging and disability, combined with technology, has created an economic and political opportunity to rewrite the narrative of aging. New business models and new technologies can combine to create a future that people will want and enjoy because it responds to their needs. Coughlin argued that successful technologies will appeal to

[1] As Joseph Agostini, senior medical director at Aetna, pointed out later in the workshop, among just Medicare beneficiaries, 27 percent have three to four chronic conditions, and 20 percent have five or more chronic conditions. Together, these groups account for almost 90 percent of Medicare costs. The 20 percent with five or more chronic conditions account for two-thirds of Medicare costs.

everyone in some way, and individuals will stop regarding these technologies as something only useful for older adults or individuals with disabilities.

Public Engagement

People continue to have faith in technology. According to one survey, 90 percent of American baby boomers said that they know how to use technology to make their lives more interesting and enjoyable (Smith and Clurman, 2007). Coughlin argued that the goal is not just to provide additional support but to excite and create a level of living that everyone can aspire to, no matter their level of ability. "If you make good technology," he said, "it responds to their needs automatically." Already, technologies are being embedded in clothes, utensils, and even in the human body to make life easier and healthier. Systems worn under clothes can increase strength and flexibility and monitor well-being. Wheelchairs can respond to voice commands to find a person or go to a specified location. A car, a home, a workplace, a nursing home, or a hospital can monitor physical states and intervene when necessary and desired. Telephones can remind people to take their medicine, call their mothers, or do anything else that needs to be done. Robots do not just clean houses; they greet people in offices and aid in physical rehabilitation. In some cases, these are technologies in search of a problem, said Coughlin. But if technologies are smart and connected and provide needed services, regardless of a person's age, they will be welcomed. The idea, Coughlin said, is to get technology out of the laboratory and into the living room.

The way to find out what people want is to talk with them and watch them. Coughlin and his colleagues use surveys and focus groups to find out what people need and what problems they encounter. A 20-something engineer or product manager may never have considered how difficult it can be to open a bottle, reach for a box of cake mix on the top shelf, or try to use a credit card reader in a drugstore checkout line. Stores can be redesigned to have the things older people need on middle shelves, lighting that makes it easier to see, and carpeting that is less likely to cause falls. Walkers can be designed to fold into canes so that older people do not need to station walking devices in all the parts of a house where they are needed.

All these technologies are either on the market or near to being on the market, but many have trouble being accepted. As a familiar example, Coughlin cited the personal emergency response systems designed to alert emergency workers in the case of an accident. Such systems were created in the 1960s and further developed in the two decades after that. Yet the market penetration of the technology among Americans 65 and older is just 2 percent, said Coughlin. Even in the United Kingdom, where the National Health Service will pay for the technology, the penetration rate is just 15 percent. Thus, even a technology that is obvious, easy, relatively affordable, and sensible has not spread widely. Until such technologies are available at such places as Best Buy and Brookstone, Coughlin said, the market will have failed the people who could benefit from those devices.

New Solutions Bring New Challenges

The acquisition and use of new technologies by older adults and individuals with disabilities is often framed as a purely rational act based on facts and fear, but this is not true of the general marketplace. For example, people buy many foods that are not good for them but simply taste good. Also, people may buy products because they enjoy and learn from the shopping experience. For example, when people go to an Apple store, they seek help at the

"genius bar" which allows them to ask questions without feeling foolish. In contrast, many assistive technologies are presented as something needed only by older adults and individuals with disabilities, not everyone else. The idea, said Coughlin, is to take advantage of teachable moments, make engaging with technology fun, and let people enjoy themselves. Similarly, he showed a photograph of an insurance company office in which people can have a cup of coffee and sit down beside a fireplace to talk with an agent. Such approaches engage more than the rational desire to make an economic transaction. Coughlin argued that this is not done very well in presenting assistive technologies to older adults and individuals with disabilities.

For many technologies associated with disabilities and aging, people have to select the technology, find a way to pay for it, install it, and fix or replace it if it breaks. Such technologies do not come with a Geek Squad that can make the technology work. Furthermore, because families are smaller today than in the past, fewer children are present to care for parents, and many of them live farther away and have jobs. Today, the fastest growing number of households in America consists of women 65 and older living alone. Many of these women do not have sons, daughters, sons-in-law, or daughters-in-law nearby who can come over and help them get a technology to work.

The challenge is to make technology easy. Technologies can detect that a person's gait has changed and that he or she is about to fall or that a person's diet has changed. But how will that information be used? Family caregivers can easily be overwhelmed by such information. The daughter taking care of an elderly parent is looking for solutions, not data, said Coughlin.

Creating data rather than solutions also raises questions of liability, safety, and risk. For example, can caregivers or family members trust a technology? Is the technology reliable? Can a caregiver check with an elderly charge less often than before the technology was used? Will technology create greater social isolation as a result? As Coughlin put it, "Do you trust the cloud with your mother?" The law uses a concept known as the "reasonable man standard," which holds that the typical member of a community ought to be able to use a technology without risk. But what if the typical user of a technology is a 67-year-old woman who is short and frail and has three or four chronic conditions? Is a new standard of reliability needed to get technologies into homes and manage risk?

Coughlin also mentioned that as more technologies are in use, people may tend to ignore the multiple alarms that occur often and are usually, but not always, false. Bad outcomes may become more likely when people rely on technologies too much.

Technologies need support and services in the community, not just in sales or call centers, if they are going to be used. Even if a technology is widely distributed, many people may need help to use that technology. If people want to age in place in their communities, the technologies they need have to be available and supported in those communities.

Many of the best ideas for technology come from people who deal with the problems those technologies could solve, said Coughlin. The people who best understand the problems of aging and disability are those who live and work in communities of aging and individuals with disabilities. Researchers develop wonderful ideas, but innovation is putting practical ideas into use. Unless a technology is at use in a living room or community, it is not an innovation.

Also, new technologies often require a new workforce. For example, most medical students are still not being taught much about telemedicine,[2] even though these technologies will

[2] "Telemedicine and telehealth both describe the use of medical information exchanged from one site to another via electronic communications to improve patients' health status. Although evolving, telemedicine is sometimes

be a major part of the future of medicine. Moreover, if students are not taught much about telemedicine, the technology will be less widely adopted than it could be and will provide fewer benefits. Coughlin stated, "Until we can get telemedicine to be called *medicine*, it is still going to be something new and different." In the future, health care providers will need to be systems integrators, but they are not being prepared for that future today. Coughlin looked to a new profession that would combine clinical and data expertise. No such programs exist today, but the need will become increasingly clear.

Concluding Remarks

Coughlin concluded with several recommendations he thought could pave the way toward such a future. He said that we need a new agency, focused on innovation, that would go beyond the Small Business Innovation Research (SBIR) model. Such an agency should help get innovations into homes and communities, in part by working with businesses to make technologies available and usable. Such an agency could establish a national agenda and get the attention of major companies to make innovations affordable, usable, and available. It could bring business, government, and the research community together to take ideas from the laboratory to the living room.

He also advocated increased support for research on both new technologies and ways of getting those technologies used. This effort will require support for marketing and product development so that imagination is converted into innovation. In addition, we need a community-based network to make the business case for an innovation.

A nationwide education initiative should link technology development in universities to the service professionals working in communities, Coughlin recommended. Today, few universities that train nurses, social workers, gerontologists, or physicians offer courses in telemedicine or other technologies.

Coughlin offered several additional policy recommendations:

- Facilitate public–private partnerships to create a smart-buyer guide of systems and service innovations for caregivers, users, and social media communities.
- Ensure technological equity and affordability through, for example, the leveraged procurement power of public agencies.
- Develop legal frameworks to address emerging issues of risk, privacy, data ownership, consent, and competence.

Coughlin closed by issuing a call to action that focuses on a dream for the future and is not just a call for more investment in research. With luck, everyone eventually will age. Leveraging political will, economic opportunity, and technological potential is therefore not just about older adults and individuals with disabilities, but about everyone. People need passion, urgency, and leadership to act on the idea that everyone should live longer and better.

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associated with direct patient clinical services and telehealth is sometimes associated with a broader definition of remote healthcare services" (ATA, 2013).

EXAMPLES OF TECHNOLOGICAL INNOVATIONS

Geoff Fernie, B.Sc., Ph.D., MI.Mech.E., C.Eng., P.Eng., CCE
University of Toronto and
Toronto Rehabilitation Institute–University Health Network

Whether a person starts off with a disability or not, he or she will probably end up with one, and probably more than one, exacerbated by multiple minor or major complications. Technology can counter these disabilities both by preventing disabilities and by providing people who have limitations with as much mobility and freedom as possible. Both approaches will become increasingly important as the percentage of older people in the population increases and as families continue to live in widely separated locations. Fernie explored the potential of technology by looking at several diverse examples.

Sleep Apnea

Fernie stated that sleep apnea affects around 7 percent of middle-aged men and a somewhat lower percentage of middle-aged women. He further stated that only 10 to 20 percent of people with sleep apnea are ever diagnosed, but their condition places them at higher risk for heart attacks, stroke, and accidents. As a result of its prevalence and effects, sleep apnea is a huge public health issue.

To receive an official diagnosis of sleep apnea, people need to go to a sleep clinic and be tested while they are sleeping. Unfortunately, the procedure is expensive and can be difficult to arrange. To address these challenges, more than a dozen competitive products have been developed to test for sleep apnea at home, such as masks that measure the amount of air flowing past a sensor. Alternative methods of treating the disorder are also being developed, offering the potential to greatly reduce this serious condition.

Hospital-Acquired Infections

Many people in hospitals acquire infections (also known as nosocomial infections) when they are being treated for something else. Many of these infections, which may kill nearly 100,000 people annually in the United States (Klevens et al., 2007), are caused by health care workers who carry an infection from one site to another because of a failure to wash their hands.

Fernie and his colleagues have developed an inexpensive technology that uses light-emitting diodes to send a coded message whenever health care workers cross a threshold, such as the door to a patient's room. If the workers have not washed their hands, badges they are wearing vibrate. When they wash their hands, the hand-washing machines emit another signal, and their badges turn green. In this way, other workers and patients know that someone has followed good hand hygiene, which can be very difficult in a busy environment where nurses can be expected to wash their hands up to 120 times in a shift. Fernie related that in a recently completed 12-month trial on a 50-bed unit that was already reporting high levels of hand washing, he and his colleagues found that the technology more than doubled hand hygiene.

Falls

Very few older people who fall and break a hip ever return to regular mobility again, and a significant proportion die within a year. Both stairs and ice are major contributors to such falls, but technology can reduce the risk substantially. A careful study of the rise and run of different steps by Fernie and his colleagues revealed a sixfold decrease in accidents as the run (the horizontal dimension) of steps is increased. Making steps deeper—through changes in building codes, for example—is a straightforward way of decreasing falls and reducing disability.

On icy surfaces, footwear can make the difference between staying upright and falling. Fernie and his colleagues have tested, in a simulation chamber, different boots and shoes on icy surfaces at different angles. Most footwear, including some expensive styles advertised as designed for snow and ice, give way on slopes of about 5 degrees. But one of the boots tested could go up and down 20 degrees of slope. With parts of Canada and the United States covered by snow and ice for substantial portions of the year, this simple technology could prevent many falls and deaths.

Another major cause of accidents is distracted walking, especially as people spend more time talking and texting on cell phones as they walk. As Fernie pointed out, the human brain is not good at dividing attention between different types of activities. For example, if someone's hearing diminishes, that person is more likely to fall. There is a fair bit of evidence that this may be due, in part, to the brain devoting more attention to interpreting the auditory environment. Fernie's group is therefore working on hearing aids that amplify only what someone is looking at. It has also developed a simulator in which someone can walk through a virtual Toronto while encountering a very precise soundscape. Another simulator can create extremely realistic driving environments—complete with unexpected challenges—which can be used in research designed to help older drivers remain safe behind the wheel.

Technologies for Caregivers

Finally, Fernie talked about technologies that can help caregivers for people who have disabilities, including family members who are caring for parents or other relatives. Family caregivers are the largest labor force in health care, and they often suffer physically and psychologically in their roles. For example, caregiving has an even higher back injury rate than mining, with many injuries caused by lifting and moving people. Electronic devices can monitor and communicate various physiological parameters and activity levels, relieving at least some of the responsibilities and stress on caregivers. Also, new devices for lifting people can obviate the need for as much heavy physical labor. Fernie demonstrated an inflatable device that can extend a strap underneath a prone person so that the person does not need to be lifted. The strap then can be attached to a lifting device.

Common tasks are often the most difficult and complex when accommodating a disability, such as going to the bathroom or getting out of bed. Fernie demonstrated a system of portable lifts and supports that can be installed in a home to make these tasks easier. But much more work needs to be done in such areas, he added. High technology is not necessarily the answer to every problem. Relatively simple technologies are still desperately needed to solve common but extremely complex problems, and these technologies need to be inexpensive if they are to be widely used.

THE CENTER FOR AGING SERVICES TECHNOLOGIES

Majd Alwan, Ph.D.
LeadingAge Center for Aging Services Technologies

The Center for Aging Services Technologies (CAST) is a program of LeadingAge that brings more than 6,000 service providers together with technology companies and researchers to expedite the process of developing, validating, evaluating, and adopting appropriate technologies that can transform aging; LeadingAge members serve more than 4 million seniors on a daily basis.[3] CAST has four strategic fronts: research, policy, standards, and education.

Strategic Fronts

Research is aimed at identifying available technologies and assessing their value and the barriers to their development and adoption. A user-centered approach to design takes into account not only the needs of the end users but also their requirements and preferences. Technologies are evaluated in living laboratories within the provider organizations serving older adults and individuals with disabilities.

In the area of policy, the program advocates for the removal of barriers to the adoption of technologies at the federal, state, and local levels. It also works on standards for interoperability and interconnectivity to ensure that these technologies are capable of providing continuity of information and care when used by multiple care provider organizations. In education, it focuses on educating providers and professional caregivers.

Technology-Enabled Care Models

After the passage of the health care reform bill, CAST conducted strategic scenario planning and identified three categories of care models that are likely to become mainstream and the enabling technologies. The first category consists of integrated and coordinated health care delivery. Under health care reform, accountable care organizations that bundle payments are representative of this model. The second category consists of community-based support services such as home care. In this case, services are delivered on an as-needed basis. The third category consists of real estate–based models where technologies are used on campuses to improve efficiencies and to leverage the capabilities to deliver services outside campuses.

All three models benefit from the use of interoperable electronic health records through which health information can be exchanged. In addition, remote patient monitoring and telehealth can manage chronic conditions, stabilize newly discharged patients, and encourage self-management. Care coordination tools allow for shared care planning and care coordination across care settings.

CAST identified future-ready technology-enabled care models (LeadingAge CAST, 2011a) and then collected a number of real-life case studies of providers who are implementing these models (LeadingAge CAST, 2011b). In addition, a report prepared for the Department of Health and Human Services systematically looks at care issues prevalent among older adults and individuals with disabilities—falls, chronic disease management, medication management,

[3] For more information, see www.leadingage.org/cast.

sensory impairment, cognitive impairment, functional decline and loss of independence, and depression—and examines the efficacy and cost-effectiveness of technologies for each (LeadingAge CAST, 2012). The report also has a chapter on barriers to the development and adoption of technologies, along with strategies to overcome these barriers. A major finding of the report concerns the variability of evidence. Some technologies have strong evidence of efficacy, and others have less evidence. Some are proven to be cost-effective, but cost-effectiveness often depends on the operational and business model in which these technologies are used. For example, remote patient monitoring and telehealth have the strongest evidence of cost-effectiveness, but most of the evidence comes from studies of the Veterans Administration, which may not be generalizable.

The biggest barrier to the adoption of these technologies, said Alwan, is the absence of business models that are conducive to their adoption. Strategic partnerships among acute, postacute, and long-term services and support are key to the use of these technologies. In addition, adoption of technologies is slow because of such barriers as the lack of awareness not only among consumers but among caregivers, physicians, and discharge planners. Technical issues related to usability, competency in using technologies, and interoperability also contribute to slower adoption.

High-Tech Aging: Improving Lives Today (Video)

Alwan played a video featuring technologies that are commercially available today and are being used by provider organizations, though on a smaller scale than in the integrated fashion envisioned in the near future.[4] The video featured the use of electronic medical records to coordinate treatment and rehabilitation for a stroke. It also demonstrated the use of telehealth technologies, in-home sensors, a medication dispenser, and a personal emergency response system with automatic fall detection to care for a person recovering from a stroke and relieve the demands on caregivers. The idea behind the movie, said Alwan, was to stimulate strategic partnerships to make these technologies and their widespread adoption a reality.

THE LEONARD FLORENCE CENTER FOR LIVING

Steve Saling
Leonard Florence Center for Living

Steve Saling was diagnosed with ALS in 2006, when he was 38. Given a life expectancy of 3 to 5 years, he decided to change how ALS patients live their lives. He teamed up with the chief executive officer of the Chelsea Jewish Foundation, Barry Berman, and together they designed and built the award-winning Leonard Florence Center for Living.[5] The residences within the center are fully automated to provide unprecedented levels of independence and productivity. As cofounder of the ALS Residence Initiative, Saling is working to replicate the residences around the country. Recently he arranged a tour of the center for Steve Gleason, a former professional football player who was diagnosed with ALS. As a result, a second ALS residence is scheduled to open in New Orleans.

[4] Video available at http://www.youtube.com/watch?v=ty83xXOt3dY.
[5] For more information, see www.leonardflorencecenter.org.

Saling's exclusive means of communication for the last 3 years has been a software program called Dasher, which enables him to control a computer with a silver dot on his glasses. For the workshop, he composed a presentation that he played for the participants:

> You may think this computer voice is sometimes difficult to understand, but I am sure you will find it easier to understand than my southern accent. I grew up just outside Atlanta and lived there until 7 years ago. I went to college at Auburn University to become a landscape architect. My work focused on designing public spaces like public parks and urban spaces. My specialty was in designing places that are fully accessible for people with disabilities. So the irony never escapes me that I am now a direct beneficiary of my previous professional work. When I was diagnosed just over 6 years ago, I had researched ALS to know that in a few years I would be totally paralyzed, unable to speak, and maybe unable to breathe. I was told that it was invariably fatal, with an average lifespan of 3 to 5 years after diagnosis. However, I knew that technology existed that would keep me alive pretty much as long as I wanted. I didn't yet understand why someone would choose death over needing a ventilator to breathe for them. Instead of being filled with grief because of my doctor's grim prognosis, I took it as a challenge and something to be proven wrong.
>
> ALS is a neurodegenerative condition that slowly makes the nerves that control movement stop working. I knew that I would have a power wheelchair when I became too weak to move on my own. I knew that I would always be able to communicate through a computer like the great Stephen Hawking. I also knew that compact portable ventilators would breathe for me when my diaphragm becomes too weak to pump my lungs. I admit to thinking that I had it all figured out 6 years ago—that was until I started shifting my research from how I was going to live to where was I going to live. I was shocked to find out that in my home state of Georgia, there was not a single facility where I could live when the time came that I needed a ventilator to breathe for me. My shock turned to despair when I finally met someone with ALS living on a vent in a chronic hospital. Here was a young guy like me whose mind remained sharp even though his body had failed him completely. I was horrified to learn that he was rarely, if ever, out of his bed but stayed in a small room that he shared with a 90-year-old gentleman. It had been a year since he felt the sun on his face and 2 years since he had a proper shower. I finally began to understand why so few people choose to take advantage of readily available technology to extend their life. The options for long-term care are so bleak that death is preferable to being left in bed, staring at the ceiling, technically kept alive but essentially warehoused, out of sight, out of mind.
>
> I was determined to find a better way to live with my ALS. I never felt that ALS would be the end of my life, just a change in its direction. Sometimes, it is better to be lucky than good. There is no way I can have hoped to be as successful as I have been. I was very able, 6 months after my diagnosis, when I met Barry Berman, who ran a nursing home and wanted to build something brand new that would specialize in younger disabled people. I was a little hesitant when Barry suggested that this new place would be a nursing home. The only thing I knew about nursing homes came from visiting my grandmother.
>
> She lived in a really nice place, but it was certainly nothing I aspired to. Barry began telling me about a new concept called a greenhouse, and I was intrigued. No matter how nice it sounded, I knew that it would have to provide vent support and be fully automated so that I wouldn't become a prisoner in my own body. Barry quickly agreed to both, and a wonderful partnership was born that in 3 short years would create the first, and so far only, fully automated, skilled-service ALS residence in the world. I couldn't believe my good fortune at having my dream fulfilled by being asked to design the perfect environment in which for me to grow old. As an architect and accessibility expert professionally, with a passion for technology, and newly included as a disabled person, I felt like the offer was a gift for which I was particularly well suited.
>
> In addition to consulting with the architects on accessibility, I accepted responsibility for designing the automation system. The design of the automation was challenging, but I would have it no other way. We hired a home automation company to create a customized automation solution that met a demanding set of specifications that I had outlined. I not only wanted to have control of everything, I wanted to make sure that any device with an Internet connection would be able to control the system with no software to install and no hardware required to be attached. The result is called PEAC,[6] and I hope and expect that it will transform the mobility for the physically disabled. My home is fully automated, so once I

[6] PEAC is the Proximis Environment Automation Controller. See http://www.peacautomation.com.

am helped into my wheelchair every morning, I am independent and able to move freely until I go to bed late that night. I have full control of my lights, doors, and thermostat. I can open and close my window shades and have complete control of my flat-screen home theater. I can call for assistance or help. All of this I can do from my computer with slight movements of my head or movement of my eyes.

If it is electrical, I can control it. Even the elevators are fully automated so that I can call the elevator and select the floor from my computer. I may be paralyzed, but I am free. PEAC is currently being marketed to other health care facilities, and I highly recommend it. It dramatically reduces the demand on staff by eliminating the calls for help every time someone wants a light on or the channel changed. Freedom is good for everyone.

As awesome and amazing is the freedom and independence provided by PEAC, it is the people who make it a home. I share a house with nine other friends, and we have people there 24/7 who are like family to help us however we ask. Barry and his administration made it their highest priority to hire the kindest, most compassionate staff. It really is an extended family. ALS does not have to be fatal anymore, and the ALS residence makes the best possible life out of a challenging situation.

Until medicine proves otherwise, technology is the cure. The same as anyone, I want independence. Despite my obvious disability, the ALS residence provides the maximum possible freedom and independence, so I have a life instead of worrying about my personal survival.

My doctor told me to get my affairs in order. Instead, I have founded the ALS Residence Initiative with the mission to inspire replication across the country. The second fully automated, vent-ready ALS residence will open in New Orleans in two months, and there are more being planned. We don't have to wait for the future to use technology that provides freedom and independence. The future is now. The challenge now is to make it common and usual. Thank you for your time, and remember, life is good.

3

Technologies to Promote Activities of Daily Living and Independence

The core of the workshop consisted of four panels—each featuring two or three speakers and a respondent—on applications of technology in different areas of personal and community life. The next four chapters summarize the formal presentations made during each of these panels. The reflections of the respondents appear in Chapter 7 as part of the summary of the discussions that took place throughout the workshop.

In the panel on technologies to promote activities of daily living and independence, Rory Cooper, FISA and Paralyzed Veterans of America chair and distinguished professor at the University of Pittsburgh, described some of the ways in which wheelchairs can overcome mobility limitations, along with mobility challenges still to be overcome. Then Gregory Wellems, chief operating officer at Imagine!, described how universal design can help make smart home features widespread and familiar.

PROMOTING INDEPENDENCE FOR INDIVIDUALS

Rory A. Cooper, Ph.D.
University of Pittsburgh

Assistive technology needs to be delivered through a team approach, but that rarely happens. In America, most assistive technology is simply purchased from a retail outlet such as Walmart, Costco, or Home Depot. In addition, rehabilitation technology suppliers are loosely regulated and not highly trained.

New technologies are also slow to emerge because of insufficient funding for research and development, especially for translational research and technology. SBIR funding is available, but a technology needs to be developed to the point that it is eligible for SBIR funding. Such funding also requires working with a small business rather than with large companies that can more easily bring a technology to market.

Finally, reimbursement for assistive technology is inadequate. Cooper is a veteran, which made him eligible for the kind of wheelchair he uses, but it is not covered by most insurance. Without his wheelchair, Cooper would have to stay wherever he was. Similarly, without a communication device, someone who cannot communicate otherwise transitions from being an independent person to a dependent person. Assistive technologies can be expensive. A sampling of mobility devices that Cooper showed for use in communities (e.g., robotic exoskeletons, prosthetic limbs) cost between $90,000 and $120,000. These devices, some of which are covered by insurance but some of which are not, challenge current reimbursement systems.

Wheelchairs

Many people in the world who need a wheelchair do not have access to one. Cooper asserted that only about 6 million wheelchairs are produced each year, and about 4 million Americans use wheelchairs, with an average wheelchair lasting 3 years. Ten years ago the average wheelchair lasted 5 years, Cooper said, but because of pressure from reimbursement, manufacturers have moved to cheaper technologies, a change that has reduced the lifetime of wheelchairs.

Wheelchairs are designed to help prevent pressure ulcers or alleviate pain, but people do not use them as prescribed. As a result, an insurance company may wonder why it spent $35,000 or $40,000 on a piece of equipment that is not treating the problem. Monitoring systems can help determine whether a chair is being used as prescribed. For example, chairs can provide information about configurations to relieve pressure ulcers, with the data being transmitted to a clinician as well so that the issue can be discussed with the patient. Most individuals do not need such a system for the long term, but it enables them to make adjustments that they then can internalize into their routine activities. Cooper also showed a technology that addresses such problems as whether a chair is tilted back too far to go up a ramp safely. The chair provides information about the angle to tilt the chair to compensate for the ramp.

Transfers from a wheelchair to another seated location are a critical aspect of accessibility. Cooper has been involved in a study to look at the heights and gaps that can be managed independently during transfers; the study found that most people can easily handle only about two inches of horizontal or vertical difference during a move.

Sports and Recreation

Sports and recreation are important modalities of rehabilitation, but the Veterans Administration and Department of Defense are the only agencies that cover sports and recreation equipment today. Activities such as bicycling, quad rugby, and wheelchair basketball provide both wheelchair skills and community integration. People typically cover about 2,500 meters of community-based activity per day, which is about the same as it has been in the past. But sports participants in wheelchairs can cover about the same amount of distance in a 1-hour game.

Technological Advances

Wheelchairs and other devices providing robotic manipulation are becoming available to help with activities of daily living. Cooper showed a person using voice control and a tablet to control a wheelchair as well as two manipulators (arm-like mechanisms which grasp and move objects) in an office supply store. Nevertheless, many places remain inaccessible to people in wheelchairs, changes in the physical infrastructure remain slow, and the kinds of wheelchairs needed to access some locations are typically not covered by insurance.

Technology for amputees is also making rapid advances. For example, virtual reality devices can help an amputee improve balance on a prosthetic. Powered ankles and knees are now on the market and will become more sophisticated over time.

Cooper described a simple magnetic device called Path Lock, which converts a wheelchair to a one-arm drive, so a user can hold something with one hand and push with the other. In addition, hybrid systems can work partly with human and partly with mechanical propulsion to increase mobility. And technologies are providing information about how

wheelchairs function, which can be used to improve their functionality and reduce risk for outcomes such as carpal tunnel syndrome or rotator cuff injuries.

Wounded Warrior Home[1]

Cooper's group has been working with several companies to create accessible housing for military personnel who continue on active duty. He showed two finished houses at Fort Belvoir, Virginia, where 120 more are planned. The homes feature keyless entry; a security system; floor surfaces that help with visual guidance; accessible tubs and showers that look more like those in a standard bathroom; technology closets in which to keep wheelchairs and prosthetics; high and low sinks and appliances in the bathroom and kitchen; an indoor room for home therapy with a door to the outside; temperature control for every room in the house; high-filtration systems for people with allergies or sensitivities to smell; turning space in all the rooms; and other features for military personnel with disabilities.

Universal design, in which all homes include the features needed to accommodate limitations, is the key, Cooper said. As people get older, they are able to use such features. When they have children, they will use these features. When people who have disabilities come to a home built using universal design, they will use those features. Such homes can be used by everyone.

PROMOTING INDEPENDENCE IN THE ENVIRONMENT

Greg Wellems
Imagine!

Imagine!, which is a private not-for-profit organization in Colorado that provided support to 2,800 people in 2011, largely assists people on Medicaid who have relatively few assets.[2] Imagine! therefore focuses on technology because technology will be essential to overcome the barriers to care faced by those without extensive resources on which they can draw.

Providers tend to throw technology at problems, technologies such as an online learning system, an online management system, an enterprise application, and a remote monitoring system. But unless these systems are tied together, they will not interrelate and work together. In addition, when smart homes or smart services are developed in universities, the people who test technologies tend to be college students pretending to have a disability, said Wellems. But the best way to develop technologies is to have people with cognitive and developmental disabilities use technologies to figure out what works and to determine where changes are needed.

Service providers need to have a strategic process to prioritize and analyze organizational "pain points." For example, a 6-inch binder full of paper is a pain point because it is static information, whereas dynamic information is needed to plan for change. Technology produces change in services and caregiver dynamics, and organizations need to plan for such change.

Universal design has to encompass technology, Wellems observed. A house can have an outlet near the top of the door so that an automatic door opener can be added at some point.

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[1] For more information, see http://www.woundedwarriorhome.org.
[2] Information about Imagine! is available at http://www.imaginecolorado.org, and information on Imagine! SmartHomes is available at http://imaginesmarthomes.org.

Ceilings can be reinforced to accommodate a barrier-free lift. Walls can be reinforced with particleboard or plywood so that a robotic arm can be added, and countertops can be adjusted up or down. Control panels can allow complete access to any outlet or device in the home so that doors or windows can be opened or closed and televisions and radios can be turned on or off. Energy use can be monitored to increase efficiency, and other kinds of dashboard systems can capture and analyze data and present that information in a meaningful way to an end user. Wellems emphasized the value and importance for these homes to be "green" since energy efficient homes save on ongoing operating costs. Additionally since these homes are typically funded through grants and private donations, green building techniques help to attract funders.

Imagine! uses a radio-frequency identification system in its homes to provide services to occupants as well as to inform caregivers and managers. The same system can be used to understand health care needs and how they change over time. For example, it can monitor the amount of time a caregiver spends with a client and how the amount changes over time. Remote monitoring systems can detect falls or proximity, provide for remote health monitoring, and compile other kinds of data. Cognitive support technology can work in any location, whether a home or the community.

Wellems pointed to a particular example of "low-hanging fruit" for promoting independence in the environment. The expertise of most corporations, he said, is in information technology, not in managing remote monitoring systems. Such expertise is increasing in some companies, but service providers are looking for more. For example, radio-frequency identification technology needs to be more reliable to use with confidence in smart homes.

Wellems also cited the success of social media, which has redefined community for people with disabilities. Social media do not recognize disabilities, he said.

Finally, he emphasized the importance of personnel. A particular caregiver may understand a particular technology, but then a new caregiver arrives who does not. Service companies will need to do a better job of writing job descriptions, recruiting employees, and training them for their positions to provide support.

The goal is not just to create smart home after smart home, said Wellems. Families are waiting, and some individuals will not become eligible for Medicaid. Technologies need to be developed and widely implemented so that smart home concepts become familiar and common.

4

Technologies to Promote Community Integration and Participation Through Community Design

The design of communities can promote the integration and participation of all family members, including those with disabilities. In the second panel of the workshop, a pair of speakers discussed two prominent features of community design. Mohammed Yousuf, research engineer at the U.S. Department of Transportation, described several radically new approaches to transportation technologies that could meet the mobility needs of people with disabilities. Jon Sanford, associate professor in the College of Architecture and director of the Center for Assistive Technology and Environmental Access at Georgia Tech, described workplace accommodations that can foster not just participation but inclusion. In both cases, these changes could have benefits for everyone, not just people with disabilities.

NEW TECHNOLOGIES FOR ACCESSIBLE TRANSPORTATION

Mohammed Yousuf, M.S.
U.S. Department of Transportation

More than three-quarters of people with disabilities say that adequate transportation is important to their daily living needs, and more than a quarter consider it a significant problem in accessing jobs. Transportation is also critical in health care, recreation, and aging in place for people with disabilities.

New Paradigm

Yousuf covered three "new paradigms" in transportation that address these needs. The first involves intelligent transportation systems, which include connected vehicle research and automated vehicle research. Connected vehicle research seeks to develop vehicles that communicate with each other and with the traffic infrastructure, such as traffic lights. Pedestrians also can be brought into the mix using wireless technologies. Automated vehicle research, which seeks to create vehicles that can drive on their own, could be an even greater boon to travelers with disabilities.

The second paradigm involves advanced research in such areas as artificial intelligence, computer machine learning, and brain-reinforced learning. Some of this research is being carried out through the SBIR program at the Federal Highway Administration and through the Intelligent Transportation Systems Joint Program Office. These programs are focused largely on mobility in general, but they also have applications for travelers with disabilities.

Finally, Yousuf mentioned synergistic approaches that combine wireless technologies, sensors, robotics, and artificial intelligence. For example, he described a system in which a pedestrian with a smart phone could communicate with the traffic signal to request more time to

cross an intersection.[1] Such a system could accommodate mobility-impaired, vision-impaired, or hearing-impaired pedestrians in ways suited to each group.

Cost Benefit

New technology solutions could result in big savings, Yousuf said. As an example, he mentioned the idea of converting some paratransit trips to fixed-route trips. If a quarter of the paratransit trips in 2010 were converted, the savings could be $1.5 billion per year. In addition, service could be better, compared with the fragmented and sometimes delayed service that exists today. Building users' needs into the transportation system at the beginning is generally less costly than retrofitting existing systems.

Understanding Users' Needs

Yousuf described four major categories of disabilities—mobility, hearing, vision, and intellectual—and focused specifically on the last category as an example. If a parent asks the question, "Did my son get on the bus?" wireless technologies could provide an answer quickly and inexpensively. Furthermore, technologies developed to overcome one type of disability can help overcome others and benefit travelers without disabilities as well. Technologies can apply to many travel modalities, including sidewalks, automobiles, buses, trains, and planes, as well as many reasons for traveling, including work, school, errands, and leisure. And technologies can be particularly powerful if they are inclusive and universal so that the same technology works in Chicago or San Diego.

Data standards are a big piece of the puzzle, said Yousuf. Is an elevator working? Is a bus wheelchair accessible? Answering such questions requires data capture and management from vehicles, cell phones, and other devices. Smart phones, cloud computing, and analysis of "big data" all could be harnessed to meet these needs if standards for data and metadata are in place.

The proper use of technology can support all aspects of travel, from the initial planning to the end of a trip. User needs can be integrated so that if someone is traveling to Chicago, for example, he or she will know if a hotel is accessible and has the kind of bathroom that is needed. Travelers will be able to get to their destinations safely, reliably, and on time.

Yousuf, who has a physical disability himself, closed with a vision of a transportation system in which he could take a Segway-type device to a bus stop, leave the device there, and then pick up a similar device when he gets off the bus, just as bike-sharing systems allow people to acquire bikes when and where they need them. People with disabilities should not have to worry about how to get from point A to point B, he said.

[1] In his presentation earlier in the workshop, Rory Cooper noted that a wheelchair travels at a typical speed of about 0.8 meters per second, which means that the average wheelchair user cannot get across the street before a streetlight changes, because streetlights are set for speeds of about 1 meter per second.

WORKPLACE ACCOMMODATIONS

Jon Sanford, M.Arch.
Georgia Tech

Workplace accommodations support the execution of work-related tasks, coordination of group and collaborative activities, transmission of office culture, and team building. They enhance work outcomes through higher individual and firm productivity, increased satisfaction with colleagues and their work, and lower levels of intention to leave their jobs. Thus, workforce accommodations have positive benefits for individuals who work and for the firms in which they work.

These accommodations are mandated by the Americans with Disabilities Act.[2] Title III of that act mandates particular technical requirements for public facilities. For the workplace, Title I of the act mandates "reasonable accommodations," which is defined as "any change in the work environment or in the way things are customarily done that enables an individual with a disability to enjoy equal employment opportunities." For example, accommodations could include changes to a job application process that enable a qualified applicant with a disability to be considered for the position, changes that enable an employee with a disability to enjoy equal benefits and privileges of employment as others, or changes to the work environment or way in which work is customarily performed that enable a qualified individual with a disability to perform the essential functions of that position. Workplace accommodations are contextual, Sanford emphasized. They encompass whatever needs to be done—within reason—with the determination of what is reasonable often a matter of cost.

Survey of Workplace Accommodations

A recent survey of 394 currently employed individuals with at least one functional limitation sheds light on the kinds of accommodations that are deemed reasonable (Williams et al., 2006). In all these cases, the satisfaction of employees with these accommodations was rated slightly or moderately lower than their importance. With the exception of hearing aids, older adults are less likely to get big-ticket items, such as modified workstations and accessible transportation. Except for hearing loss, receiving no accommodations consistently increases with age.

Vision Limitations

Employees with vision limitations reported receiving such accommodations as reading aids, electronic media scanners, magnifiers, enlarged print, Braille documents, antiglare devices, new displays, assistants, and redesigned jobs. Nonetheless, 12 percent of 18- to 54-year-olds, 17 percent of 55- to 64-year-olds, and 50 percent of employees older than 64 reported receiving no accommodations at all (see Table 4-1).

[2] Americans with Disabilities Act of 1990, Public Law 336, 101st Congress, 2nd sess. (July 26, 1990).

TABLE 4-1 Percentage of Adults Reporting Accommodations for Vision Limitations

Group	Electronic-Formatted Materials (OCR)	Screen Reading Software	Braille-Formatted Materials	None Provided
18–54	10%	14%	7%	12%
55–64	7%	7%	4%	17%
65+	0%	0%	0%	50%

SOURCE: Williams et al., 2006.

Hearing Limitations

For people with hearing limitations, typical accommodations included hearing aids, written communication, communication devices, sign language, ear protection, redesigned jobs, and assistants. In this case, 21 percent of 18- to 54-year-old employees, 12 percent of 55- to 64-year-old employees, and 17 percent of employees older than 64 reported receiving no accommodations, suggesting that older people with hearing limitations are more likely to receive accommodations than older people with other kinds of limitations (see Table 4-2).

TABLE 4-2 Percentage of Adults Reporting Accommodations for Hearing Limitations

Group	Hearing Aids	Written Communication	Sign Language	None Provided
18–54	29%	17%	12%	21%
55–64	39%	19%	6%	12%
65+	39%	14%	3%	17%

SOURCE: Williams et al., 2006.

Cognitive Limitations

For people with cognitive limitations, accommodations to help them attend to their tasks included checklists, reminder devices, timers, job coaches, assistants, and redesigned jobs, but 32 percent of 18- to 54-year-old employees, 42 percent of 55- to 64-year-old employees, and 50 percent of employees older than 64 reported receiving no accommodations (see Table 4-3). Some cognitive limitations are hard to prove, Sanford said, and sometimes people do not want to ask for an accommodation or do not want others to know that they need an accommodation.

TABLE 4-3 Percentage of Adults Reporting Accommodations for Cognitive Limitations

Group	Checklists	Reminder Devices	None Provided
18–54	25%	22%	32%
55–64	26%	11%	42%
65+	25%	13%	50%

SOURCE: Williams et al., 2006.

Mobility Limitations

For people with mobility limitations, accommodations to maintain body position include modified workstations, ergonomic chairs, and steps and lifts. For these limitations, 43 percent of

18- to 54-year-old employees, 45 percent of 55- to 64-year-old employees, and 36 percent of employees older than 64 reported receiving no accommodations (see Table 4-4).

TABLE 4-4 Percentage of Adults with Mobility Limitations Reporting Accommodations to Maintain Body Position

Group	Modified Workstation	Ergonomic Chairs	Steps or Lifts	None Provided
18–54	24%	20%	13%	43%
55–64	25%	25%	5%	45%
65+	14%	29%	21%	36%

SOURCE: Williams et al., 2006.

Dexterity Limitations

Finally, with dexterity limitations, accommodations include equipment modifications, gripping aids, carts, custom devices, clamping devices, leverage aids, lifts, hoists, measuring tools, assistants, and redesigned jobs. In this case, 15 percent of 18- to 54-year-old employees, 21 percent of 55- to 64-year-old employees, and 21 percent of employees older than 64 reported receiving no accommodations (see Table 4-5).

TABLE 4-5 Accommodations for Dexterity Limitations

Group	Buddy System	Assistant	Equipment Modifications	Gripping Aids	None Provided
18–54	14%	12%	11%	11%	15%
55–64	21%	11%	5%	5%	21%
65+	7%	14%	7%	7%	21%

SOURCE: Williams et al., 2006.

Barriers to Workplace Participation

Accommodations tend to be abandoned over time, Sanford reported. Sanford described data collected in an unpublished study by the Rehabilitation Engineering Research Center on Workplace Accommodations at the Center for Assistive Technology and Environmental Access at Georgia Tech. This telephone survey of 54 vocational rehabilitation clients found that 38 percent never used their accommodations or discontinued use within 1 year, and two-thirds discontinued use within 5 years (see Figure 4-1). Among those who abandoned an accommodation, one-third left their accommodations behind when they left a job and could not take the accommodation with them. Another third abandoned a technology when it became outdated.

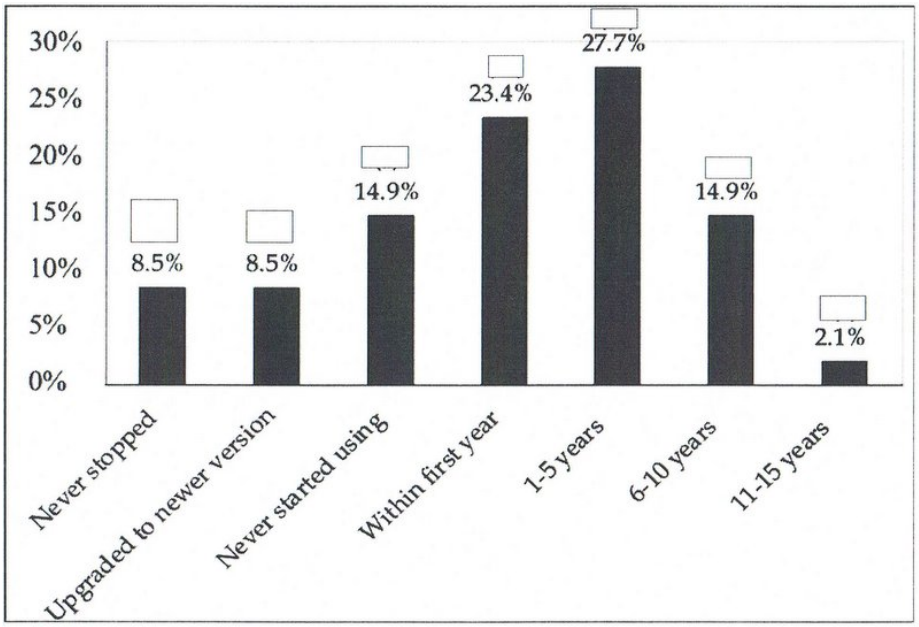

FIGURE 4-1 Abandonment of workplace accommodations over time.
SOURCE: Reprinted with permission from Jon Sanford, Georgia Tech.

Abandonment of a technology is just one of several barriers to participation that Sanford cited. Others include negative attitudes on the parts of employers and coworkers, lack of awareness about available accommodations, the inaccessibility of technologies, the lack of acceptance of accommodations, and the technologies' expense. Sanford also cited three less obvious barriers to obtaining the right technology. A technology may produce workplace activity but not workplace participation if an employee is not able to engage in a shared experience that creates a sense of belonging. Similarly, accessibility implies access not only to spaces but to conversations, meetings, social events, and the other aspects of the workplace. An employee may not be able to get to the cafeteria, participate in a training session, or even go to a Christmas party if it is in an inaccessible place. Awareness and understanding of how to keep people engaged in the workplace, and not just in work, is the issue. True participation implies a sense of belonging, inclusion, and recognition that a person's work is adding value to a workplace.

Part of the problem is that workplace participation still draws on a paradigm based on the Americans with Disabilities Act, which is focused on the performance of activities as a measure of participation. But a better paradigm for the 21st century is the framework of the International Classification of Functioning, Disability, and Health (ICF), in which accommodations for both work tasks and inclusive interactions lead to participation. Activity and participation are linked, but they are independent and equally important outcomes. For example, Sanford and his colleagues found that employed individuals with disabilities have unmet needs in shared workspaces more frequently than in their individual workspaces. And those with unmet needs have a much higher level of dissatisfaction with activity and participation outcomes than people without disabilities who do not have unmet needs.

The policy implication Sanford drew is that the assumptions within the American Disabilities Act about activity leading to participation are not supported. In the ICF, activity and participation are independent constructs, and they require different types of technologies to facilitate both activity and participation.

Emerging Technologies and Approaches

Sanford pointed to several examples of emerging technologies that can increase the participation of employees with disabilities in the workplace. Telepresence robots, devices that allow for mobile videoconferencing, can bring people in remote locations together to collaborate or provide remote job coaching and training. Collaborative software and applications of social media can coordinate distributed teams and enhance social inclusion and networking, especially for teleworkers. Gaming platforms or virtual reality can be used for training, collaboration, and social interactions. Augmented reality, which involves superimposing content onto a scene that is either in physical space or a computer-generated image, can be used as a navigation tool, provide coaching for specific tasks, or offer job training. Finally, universal design can incorporate accessibility technologies into the everyday design of product and spaces to support both activity and participation. Universal design in the workplace can benefit workers both with and without disabilities across an employee's work life. Universal design features save time, money, and effort. And workers no longer have to leave accommodations behind because they already exist in the workplace.

5

Technologies to Promote Community Integration and Participation through Social Connectedness

Social connectedness offers another way to promote community integration and participation. Judy Brewer, director of the Web Accessibility Initiative for the World Wide Web Consortium, described the abundant and rapidly proliferating ways in which information technologies can augment social connectedness for people of all ages. Clayton Lewis, consultant to the National Institute on Disability and Rehabilitation Research (NIDRR) of the U.S. Department of Education (on leave from the University of Colorado), focused specifically on the use of these technologies by older people. As with the physical environment, universal design can span age groups and the spectrum of limitations.

WEB ACCESSIBILITY

Judy Brewer
Web Accessibility Initiative, World Wide Web Consortium;
Massachusetts Institute of Technology

The World Wide Web provides people with access to the world. It offers news, information, online learning, civic participation, health care, social networking, entertainment, and more. It also represents the space in which many digital technologies are converging, which makes it a focus of both accessibility challenges and accessibility solutions.

Because of the Web's steadily increasing importance, maintaining accessibility across all Web environments is essential for healthy aging, whether someone has a disability or not. In addition, a strong business case for Web accessibility exists, involving technical carryover benefits (that is, Web accessibility also has benefits for individuals without disabilities), long-term financial benefits (due to efficiency of building to Web standards), social responsibilities, legal requirements for accessibility of information technology, and the growth of the independent living movement and disability rights culture. And people expect mainstream technology to be accessible and to address their needs in the community, with seamless access in health care settings.

As with the physical environment, universal design is a key aspect of Web accessibility, said Brewer. As Ron Mace, founder of the Center for Universal Design in Raleigh, North Carolina, has put it, universal design is the design of products and environments to be usable by all people to the greatest extent possible without the need for adaptation or specialized design. Thus, universal design defines the user very broadly. In the context of the Web, universal design implies that everyone matters when it comes to design. Thus, compatibility and interoperability with assistive technology are critical elements of universal design for the Web.

Web Accessibility Initiative

The World Wide Web Consortium (W3C) is an international vendor-neutral organization that develops standards for the web. Hosted by the Computer Science and Artificial Intelligence Laboratory at MIT, the European Research Consortium for Informatics and Mathematics, and Keio University, W3C encompasses an expanding range of technologies as broadcasting, publishing, entertainment, and games all move increasingly to the Web. One of the four main technical divisions of W3C is the Web Accessibility Initiative, which includes multiple layers of work to support Web accessibility.[1] The initiative covers not just hypertext markup language (HTML) but another 100 or so technical specifications that run on the Web. It identifies accessibility barriers, evaluates resources, conducts education and outreach, coordinates with research, and works to harmonize standards. W3C takes a multi-stakeholder approach that encompasses government, academia, industry, and the disability community. It seeks to build consensus through an open and transparent process that is responsive to input from different sources, including the public.

As examples of the work done by the Web Accessibility Initiative, Brewer pointed to captioning and signing for people with auditory limitations; cognitive and neurological assistance through consistent navigation, appropriate language levels, graphics, and a lack of flickering or strobing that could cause seizures; physical or speech accommodations for people who need to rely on keyboards, touch, eye gaze, head mouse, speech, or other alternatives to speech; and visual consistency through descriptions for graphics and audio and interoperable assistive technology. The initiative has packaged these concepts in a set of accessibility principles, which urge that Web content be

- perceivable
- operable
- understandable
- robust

The Web Accessibility Initiative also has a motivational context so that people understand the need for accessibility and act on that need. It provides training, demonstrations, sample code, and other forms of implementation support for accessibility efforts. It supports accessibility at the technical level across the expanding range of devices. International standards for Web content accessibility have been endorsed by international standards organizations, including the W3C, with provisions for the addition of future technologies. Web developers can customize the standards to the technologies being used in an organization. User accessibility guidelines cover the entire Web space and pay particular attention to mobile accessibility.

The Open Web Platform ties together the current generation of Web technologies, including mobile devices, tablets, traditional desktops, and kiosks. The Web Accessibility Initiative has been working to build accessibility into the platform so that it will conform with the goals of universal design. For example, interactive menus and drag and drop capabilities should be accessible to people using assistive technology. Independent user interfaces should add capabilities for touch, gestural, and speech control of Web content. Accessibility should be built in and capable of extension.

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[1] For more information, see http://www.w3.org/WAI.

Concluding Remarks

Accessibility solutions largely exist, said Brewer, though continued research is needed to keep up with new advancing technologies. Accessibility policies need to be in place throughout organizations, with end-to-end project management approaches, and training needs to be available where needed. The Web Accessibility Initiative offers resources on getting started, guidelines and techniques, planning and implementing, evaluations of accessibility, presentations and tutorials, and other ways of getting involved with the initiative. Support for future research and standardization efforts in multi-stakeholder forums will continue to promote awareness as well as ensure implementation for newer accessibility solutions as they become available.

CLOUD COMPUTING

Clayton Lewis, Ph.D.
National Institute on Disability and Rehabilitation Research

Lewis began by quoting his late mother: "The Internet is a corner I will not turn." How can an intelligent, capable, older person be convinced to take advantage of the technological opportunities that are available? he asked.

Drawing on an example offered by Gregg Vanderheiden at the University of Wisconsin–Madison, Lewis showed a picture of a typical computer screen. If described as an image of windows, Lewis's mother would say, "There are no windows there." If told to click on a scrollbar, she would say, "What's a scrollbar?" As an example of a technology suited to his mother, Lewis showed a computer screen developed by Vanderheiden's group, in which e-mails appear as conventional paper envelopes with printed pages inside. He also showed an animation in which a mail truck comes onto a screen and picks up an e-mail icon so that a computer user knows that an e-mail has been sent. Finally, Lewis showed a photograph of binders containing printouts of some 2,500 message that his mother had sent and received by e-mail using programs designed to overcome the complexity of electronic communications, developed by CaringFamily LLC. Even people who do not want to turn the Internet corner can take advantage of technology if provided with answers to their problems, he said.

Cloud-Based Accessibility Technology

The Global Public Inclusive Infrastructure Initiative,[2] supported by NIDRR and led by Gregg Vanderheiden, has been working to improve the user experience for computer users with disabilities by allowing those individuals to store their needs and preferences online and then autopersonalizing online content and services on the basis of those stored settings. For example, someone could store a need for larger font sizes. Every time that person used a digital device, those preferences would be reflected in the experience. Such a system would help not just people with disabilities but everyone who uses digital devices.

NIDRR also sponsors other accessibility initiatives, mostly through partnerships with other federal agencies. For example, NIDRR and the National Institute on Standards and Technology are engaged in a cloud computing project that is assessing cloud-based accessibility

[2] For more information on the Global Public Inclusive Infrastructure Initiative, see http://www.gpii.net.

technology; the two agencies also have a visualization and usability group that is looking at cloud-based accessibility for inclusive voting. With the Department of Education, NIDRR is examining cloud-based online educational assessment for children with cognitive disabilities and accessibility information in a metadata framework for online educational resources.

Opportunities

Cloud-based accessibility technology opens a wealth of opportunities, said Lewis. This technology supports not only family communication but community communication. For example, many people move late in life, which often means breaking community ties. Technology can help people maintain ties with church groups or civic organizations even when they are not in the same community. As Lewis pointed out, people are much more likely to maintain their high school friends now than in the past because of applications of technology. Technology can also enhance community participation, as when social media help people with disabilities interact with their communities or take advantage of educational activities and resources.

Technology can help people manage personal data, such as the forms for applying for services and establishing eligibility. People can get assistance on demand when needed from trusted parties. For example, someone who sometimes gets disoriented in the community could know that they could always call for help.

A major initiative called the National Strategy for Trusted Identities in Cyberspace is developing ways to make online transactions safer, faster, and more private, which could have important implications for people with disabilities.[3] Further opportunities for cloud computing include developing improved technology for creating accessible content and services, supporting the sharing of experience among technology consumers, and using big-data techniques on data from cloud-based services to improve services. For example, a big-data initiative could collect data in different ways that allow for the extraction of structured information and the improvement of services.

Concluding Remarks

If these opportunities are realized, Lewis concluded, everyone can have access to greatly expanded and improved services. Nevertheless, there is a big but, Lewis said. Accessibility technology must be incorporated into the infrastructure that everyone uses, not just provided for people with disabilities. Otherwise, services for people with disabilities will continue to be expensive and limited and will constantly lag behind those available to the public at large. Support for work such as the Web Accessibility Initiative of the World Wide Web Consortium, and the Global Public Inclusive Infrastructure initiative, he said, is crucial.

[3] For more information, see http://www.nist.gov/nstic.

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Health Management and Promotion

Another major use of technology is for health management and promotion. Joseph Agostini, senior medical director at Aetna Medicare, cited two examples of health monitoring among this group to draw broader lessons about opportunities and continuing barriers. Carolee Winstein, director of the Optimizing Participation through Technology Rehabilitation Engineering Research Center at the University of Southern California, analyzed four factors that together are forestalling the onset of disability. And Timothy Bickmore, associate professor in the Department of Computer and Information Science at Northeastern University, described a particular technology he has helped develop to improve interactions with patients. Such applications will continue to proliferate as the population ages and technology advances.

HEALTH MONITORING

Joseph V. Agostini, M.D.
Aetna Medicare

Ideally, geriatric care management is a holistic, integrated experience characterized by dedicated teams, prevention of disease, chronic disease management, risk management, and responses to major health events. It matches tools, resources, benefits, and care management programs to improve health outcomes. It sees the whole person physically, intellectually, emotionally, and financially. Agostini used two examples of health monitoring in older populations to derive a broader set of lessons learned.

Aetna Hypertension Program

Agostini stated that high blood pressure affects about two-thirds of people who reach Medicare age, and 50 percent of people are inadequately or suboptimally treated for the condition. The Aetna Hypertension Program offers an automated blood pressure monitor at no cost to people who volunteer for the program. Once a month, in response to an interactive voice response call, participants record their blood pressure and enter their results along with answers to a series of questions over the phone. They also receive supplementary educational mailings about hypertension, conditions associated with hypertension such as hyperlipidemia, and other topics. If participants have an out-of-range blood pressure, they get immediate feedback from a nurse case manager. The goal is to encourage self-management over time. As people gather data and enter information into the phone, they learn about their blood pressure and about things they can do to manage their condition.

A review of the program found that about 18 percent of people who started in the program moved from out-of-control blood pressure to in-control blood pressure by the end of the study (Wade et al., 2010). Low density lipoprotein (LDL) screening rates increased approximately 90 percent, and 87 percent of survey respondents said they knew more about

controlling their blood pressure as a result of the program. Economic modeling showed that if just 8 percent of eligible candidates participated in the program, better management of blood pressure could result in 23 fewer strokes, 22 fewer coronary artery disease events, and 16 fewer deaths per 100,000 people annually. In reality, more than 20 percent of eligible candidates chose to participate in the program, which will hopefully lead to even better outcomes in the long term.

Agostini identified a number of opportunities generated by the program. This low-technology intervention relies on phone communications rather than the Internet, which many older people still do not use. By entering and sending information to a central location, people learn more about their blood pressure than they would if the data were monitored and relayed to a central location automatically. Also, having nurses available for management backup allows for more efficient use of higher-cost resources.

Agostini also described several barriers revealed by the program. Adherence rates can wane, which often happens when people are asked to interact with a technology over time. Some participants prefer to interact with a human rather than entering their data into an automated system. Also, nurse case managers are trained in motivational interviewing, can respond in a thoughtful way, and understand what motivates people to make health behavior changes. This personalization cannot be done as well with an interactive voice response system.

Congestive Heart Failure Telemonitoring

The second example Agostini described involves biometric monitoring for congestive heart failure. Congestive heart failure is the number one cause for readmissions to the hospital, yet many of these readmissions are avoidable with high-quality care management. In this program, people at high risk of congestive heart failure had a device installed in their homes that allowed for blood pressure monitoring, weight management, and other biometrics as needed. Researchers then studied the difference in outcomes between a group of patients who had case managers versus a group who had both case managers and the monitoring technology.

The researchers found no significant impact for this intervention on hospitalizations, emergency department visits, or death (Wade et al., 2011). Part of the reason for the negative results may be the effectiveness of the case managers, said Agostini. Also, converting data from telehealth monitoring into actionable information turned out to be difficult, even though the alerts prompted more frequent telephone contact (which also had the effect of increasing case managers' workload). A similar study at the Mayo Clinic for older people with multiple chronic conditions also had negative results on hospitalizations and emergency department visits (Takahashi et al., 2012).

Participation is lower when people are invited to participate in a program than when the program is implemented through physicians' offices as part of the patients' health care, Agostini noted. Also, the installation and maintenance of the devices took more effort than anticipated. Finally, deciding which patients to recruit to the program was difficult, because it is not clear which patients would benefit most from such a program.

Concluding Remarks

Technology and connectivity will continue to improve and will become cheaper, which could improve outcomes in the future. Also, closer collaboration is likely to yield better results. In particular, teams in patient-centered medical homes and accountable care organizations could work together to keep people healthy and out of the hospital. Technology provides tremendous

opportunities, Agostini concluded, but it is a tool and not an end in itself. The goal is to increase the quality of health care at reasonable costs by increasing patient engagement and improving clinical outcomes.

REHABILITATION SCIENCE

Carolee J. Winstein, Ph.D., PT, FAPTA
University of Southern California

New technologies are changing rapidly and have great promise. But technological change also creates challenges in translating advances into practices that address real problems. According to Winstein, solutions will come through effective collaborations at the nexus of new technologies, aging, and disability among those working in a wide range of fields, including

- rehabilitation engineering
- psychological science
- implementation science
- gerontology
- clinical science
- social science
- cinematic arts
- health economics and policy
- the health care industry
- consumers

Winstein compared the nexus subfield of rehabilitation to a tetrahedron in which four major forces are coming together to forestall the onset of disability (see Figure 6-1).

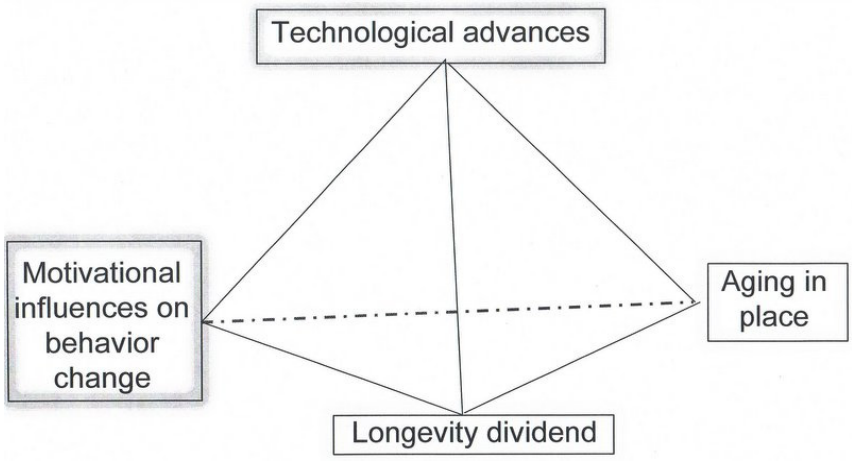

FIGURE 6-1 Four factors combining to transform the subfield of rehabilitation.
SOURCE: Reprinted with permission from Carolee J. Winstein (2012).

Technological Advances

At one corner of the pyramid are technological advances such as mobile health monitoring devices, commercial devices such as the Kinect sensor, emergency notification devices, virtual reality and game-based rehabilitation devices, and applications of smart phones, tablets, and computers. As an example, Winstein mentioned an elastic tape that is placed on a person's back and monitors posture over the course of the day. Similarly, the use of robotics for assessment and rehabilitation has expanded rapidly. A PubMed search for "robotic rehabilitation stroke" that she did returned 394 hits, with 196 since 2010.

Motivational Influences on Behavior Change

At another corner of the pyramid are motivational influences on behavior change, which Winstein analyzed in terms of three fundamental psychological needs: autonomy, competence, and social relatedness. Autonomy involves the need to determine or feel in control of one's actions. For example, simply giving people a choice can increase autonomy. Competence relates to the need to perceive oneself as capable. For example, giving people feedback that they have been successful doing something makes them feel good. This is particularly an issue for people engaging in rehabilitation, who often do not feel competent because of a loss of function. Finally, social relatedness involves the need to feel included, accepted, or connected to others. For example, the use of social media can increase satisfaction in one's involvement in the social world.

Virtual-reality simulation technology is ideally suited to incorporate these basic psychological needs, Winstein observed. Best practice in rehabilitation is focused on a specific skill or task, has adjustable levels of difficulty, is quantifiable in order to assess progress, is administered repetitively and hierarchically to allow the right amount of challenge, provides the user with feedback about success, has some relevance to real-world function, and motivates and engages the user. Virtual reality–based exercise programs can achieve all these ends.

Aging in Place

At the third corner of the pyramid is aging—and rehabilitation—in place. Rehabilitation is not something that happens just in the hospital or clinic. It can also happen at home and in the community. Closing the gap between the current evidence base and common practice could keep seniors and people with disabilities in their homes and communities longer. For example, one of the greatest fears of seniors in surveys is that they will fall and lose their autonomy. Winstein described a technology-based program called Preventing Falls in Aging People Living Locally, or PreFALL. This interactive app and Web-based system for health professionals and patients will enable them to use current evidence to identify and decrease risk factors for falling, identify and implement behaviors to prevent falling, and maintain healthy behaviors after one or more initial falls. It uses psychological theory, the best evidence from implementation science, and leading technology to create an interactive system that clinicians and patients can use through the convenience of their smart phone, tablet, or computer. This is an excellent example of how to close the gap between theory and practice in care for older adults and individuals with disabilities, said Winstein.

The Longevity Dividend

At the fourth corner of the pyramid is what Winstein termed the longevity dividend, which refers to the health, social, and economic benefits that result from slower aging. As an example of how to realize this dividend, Winstein described work being done at her center that uses the Kinect camera with seniors as they reach for virtual objects. By monitoring the cognitive load on participants, researchers have for the first time determined that the heightened attention during the virtual reality–based activity is associated with higher engagement in the task. The higher engagement leads to sustained participation and a more active lifestyle. The project has provided a wealth of data that improve our understanding of how these new technologies benefit those aging into and with disabilities. The increase in average lifespan was the great success of the 20th century, Winstein observed. The great challenge of the 21st century is disability.

HEALTH BEHAVIOR

Timothy Bickmore, Ph.D.
Northeastern University

Bickmore described a particular technology that he and his students have been developing for the past eight years to implement health behavior change interventions. They have studied one-on-one, face-to-face counseling conversations between health providers and patients to understand the verbal and nonverbal cues that go on in such conversations. They have examined not only the verbal content of the conversations but the nonverbal channels such as the use of hand gestures for conveying information, gaze cues for taking turns, body postures, head nods for understanding, and facial displays of emotion. Face-to-face communication, in conjunction with written communication, is the best means of conveying information to patients. Still, most health professionals have extremely limited time to spend with patients.

By emulating human relationship-building behavior to create and maintain a trusting therapeutic alliance, virtual characters can maintain engagement for longitudinal inventions. Bickmore and his team simulated the patient–provider interactions they observed with as much fidelity as possible in automated health care providers. Patients need to like and trust a virtual character so they will keep talking to it over time and follow its recommendations. Thus, the characters rely heavily on nonverbal cues such as facial displays of empathy, simulating closer proximity, orientation toward the patient, more facial animation, more direct gaze or smiling, and other cues that would be difficult or impossible to create in a text-based system. Bickmore and his colleagues have even conducted studies where the character has a human backstory, and patients react positively and log in more frequently to home-based interventions when the character has this human dimension (Bickmore et al., 2010).

Virtual Discharge Nurse

Bickmore demonstrated such interactions with an automated virtual discharge nurse developed with clinicians at Boston Medical Center (Bickmore et al., 2009). A computer that contains information about a patient is wheeled next to the patient before discharge. The patient then has a half-hour conversation with the virtual nurse about self-care procedures at home. The nurse talks using synthetic speech, and the conversation is dynamically assembled from the

patient's medical record. The simulated nurse has hand gestures, gaze cues, and body posture shifts that are synchronized with speech. The patient interacts with the nurse by choosing options on a touchscreen. Patients can be trained to use the system in seconds, after which they can use it on their own.

The system has been used with about 200 patients in a safety-net hospital where patients typically have low levels of computer and health literacy. When asked whether they would rather have their discharge instructions from the automated nurse or a real nurse, 70 percent choose the automated character, saying that it provides them with a more relaxed environment to get the information they need and have questions answered. Indeed, the highest levels of acceptance are in patients who have low computer health literacy.

Health Behavior Change Interventions

With a variety of collaborators, Bickmore's team has used the system for various health behavior change interventions, from medication adherence for antipsychotic drugs to breast-feeding promotion. At the workshop, he focused on a particular line of research involving exercise promotion in older adults. In one of their studies, 21 geriatric ambulatory patients from Boston Medical Center, half of whom had no experience with computers, received a touchscreen computer to use at home for two months (Bickmore et al., 2005). They also received pedometers to wear and had a 10-minute conversation with an automated exercise coach every day. Overall the patients responded positively to the automated coach, and especially to the social dimensions of the interactions. They had a high level of desire to continue using the system at the end of two months and were disappointed when the trial ended. The interactions doubled the amount of walking they did relative to a control group who were just given pedometers and log sheets. As one patient said of the coach, "She's nice. She's really good. Really good. She asks you the right questions. She tells you if you're not doing up to par, you know, and all that. And if you're doing good, she'll tell you. If you're not she'll tell you. And it's honest. And it works. It really does. I like it. I like talking to her."

They also looked at exercise promotion in patients with Parkinson's disease (Ellis et al, 2013). Twenty patients given a touchscreen system to take home for a month had high levels of interacting with the coach, closely followed the recommendations for walking, and exhibited clinically meaningfully outcomes.

Finally, Bickmore mentioned a project involving a linguistically and culturally tailored version of the system for use with an older adult Latino population in San Jose, California (King et al., 2013). Participants came to a community center twice per week for 4 months and had a conversation with a virtual coach. Again, the intervention group exhibited significantly increased levels of exercise as compared to a control group.

Concluding Remarks

Virtual agents can provide always-on social support for older adults, Bickmore concluded. They can provide wellness counseling, promote exercise, and encourage social engagement. A potential barrier is maintaining engagement over the long term. After 1,000 conversations, will patients want to continue interacting with their virtual coaches? Hardware and network connectivity are also continuing issues for patients. But simulation of human behavior can lead to increased accessibility, engagement, adherence, and retention, and it is especially effective for disadvantaged populations.

7

Reflections on the Presentations

The final chapter of the workshop summary combines the remarks made by formal respondents following the panel presentations with observations made during the discussion sessions over the course of the workshop. It thus looks back on the themes of the workshop presented in Chapter 1 and forward to possible future actions for the Forum on Aging, Disability, and Independence.

Hunter Peckham, Donnell Institute Professor of Biomedical Engineering and Orthopaedics at Case Western Reserve University, reflected on the presentations in the panel "Technologies to Promote Activities of Daily Living and Independence" (Chapter 3). Seth Bravin, strategic industries program manager with the IBM Human Ability and Accessibility Center, reflected on the presentations in the panel "Technologies to Promote Community Integration and Participation through Community Design" (Chapter 4). Marc Perlman, global vice president for health care and life sciences industry at Oracle, reflected on the presentations in the panel "Technologies to Promote Community Integration and Participation through Social Connectedness" (Chapter 5). Finally, G.P. Li, professor of electrical engineering and computer science, chemical engineering and materials science, and biomedical engineering at the University of California, Irvine, reflected on the presentations in the panel "Health Management and Promotion" (Chapter 6).

OVERCOMING BARRIERS OF COST AND AWARENESS

P. Hunter Peckham, Ph.D.
Case Western Reserve University

Peckham focused on the problems of affordability and awareness that plague the use of technology by older Americans, including those with disabilities. Devices available two decades ago had more capabilities than devices available now because cost-containment systems are driving manufacturing. The cost margins in facilities such as nursing homes are so small that integrating technologies into those facilities is difficult. Building communities that incorporate the best ideas quickly runs into financial constraints.

New models could make people aware of what technologies are available or on the way and how to make those technologies available to people, Peckham said. Today, many people do not know about technologies until those devices are critically needed, resulting in a crisis. But awareness can drive demand. For example, many corporate presidents have aging parents, and they could help create a greater awareness of the opportunities and needs. The communities involved in aging and disability need to reach out to corporations and other prominent societal institutions to foment change.

Peckham also asked whether the community of people involved with aging and disabilities is talking too much to itself. Everyone at the workshop knows about the magnitude of the problem, but the broader community in general does not.

Other Comments

Forum member Thomas Edes, U.S. Department of Veterans Affairs, mentioned possible simple approaches to supply people with information, such as making the information available at Walmart pharmacies, libraries, or kiosks in public places. People could ask such questions as what to do if they can no longer turn the lights on and off or how to get places in a wheelchair. This information could be complied into an index of frequently asked questions, which could then be made broadly available. Industry could be interested in those answers, as would agencies such as the Department of Veterans Affairs.

David Dring, SelfHelp, called attention to what he called trigger points—occasions in an individual's life when he or she is particularly receptive to new information. For example, some companies that specialize in taking baby pictures do all of their marketing in obstetrics units within hospitals. We should think similarly about other people at various stages of their lives and the different kinds and levels of help they need. Then we should inform/market our services with information and support at those times/trigger points.

THE INTERFACE WITH THE WORKPLACE

Seth Bravin, M.B.A.
IBM Human Ability and Accessibility Center

Bravin called attention to several workplace issues that can have implications for older Americans. Having a centralized budget for accommodations can make a big difference for integration and participation, Bravin said. Without a centralized budget, individual managers need to cover the cost of accommodations, which can severely limit the number of employees with disabilities and the technologies available to those employees.

He also pointed out that IBM has a workplace portal where people can request accommodations for both permanent and temporary disabilities. For example, if someone is recovering from a broken arm, that person can access an appropriately designed computer. Or if someone is pregnant and needs accommodations, or if a webcast needs to be captioned, situational disabilities can be covered.

Finally, IBM developed a mobile application called Access My City for New York City, in which people with disabilities, including mobility limitations, can check whether they will be able to get where they need to go. For example, Bravin, who is deaf, recounted an episode where he was flying to Austin, Texas, and missed a connection in Atlanta because he did not have access to an announcement made over the public address system. With Access My City, he could have captured that information and put it to use, which might have also benefited other people who missed the announcement.

Other Comments

Joseph Agostini said that if a technology works in a subset of the population and has benefits for employers or for the health care system, then it will have legs. Quality and efficiency will go hand in hand. Technologies need to show that they can be cost-effective, or it will be difficult for them to move forward.

Jon Sanford responded that working at home is a good accommodation for many people, but it does not necessarily create participation in the workplace. Social media technologies are a possible solution to that problem because they can involve people in the workplace from remote locations, creating the interactions of physical space in a virtual space.

Forum member Kelly Buckland, National Council on Independent Living, pointed to the human rights dimensions of accessibility. Much of the increase of accessibility emerged from a focus on human rights, often pushed by the disability community, not from the development of technology.

THE POTENTIAL OF THE WEB

Marc Perlman
Oracle

The Web is an enabler, said Perlman. It is a transport mechanism, a highway that connects cities, information, health care systems, and consumers. It needs to have standards but also be open so that people can travel on that highway using any type of vehicle that meets their needs. In that way, the Web provides access while making resources available.

People want to be in control when they are traveling on this highway, Perlman continued. They want to control their health care information, schedule office visits, connect with their health care providers, and have security. In a way, the Web is analogous to the smart homes being developed for veterans with disabilities, where the temperature, access, lighting, and security can be controlled by the occupants. Smart homes, like the Web, provide capabilities and opportunities to do interesting things.

People should think about not only their own needs but about those of the people they care for, such as aging parents. Health care, and care in general, is moving outside of health care settings, which requires connectivity, information, and control. There will not be enough health care providers in the future to meet the needs of an aging population. Many different people will become caregivers, and monitoring and care giving will become at least partly automated. And when automation is not sufficient, technology can make sure the right person is there to provide care at the right time.

In the future, the customer experience will involve safety nets, self-care, and personalized information. Through big data techniques, digital footprints will be mined for information to create predictive analytics, which in turn will lead to interventions. For example, someone at risk of suicide can be monitored in multiple ways to gather data that can be used to take preventive measures. New products and new solutions can help people live independently, regardless of what challenges they have, while remaining connected to the resources they need to live well.

Other Comments

In response to a question about how to connect people into the Web who are not now connected, Judy Brewer said people of all ages fall along a continuum of computer literacy and use. The design of technology can help everyone advance along this spectrum. For example, online registration systems for medical diagnostic procedures can facilitate or hinder access to care. Technology itself can accommodate disabilities so that people are better able to access information or resources. Regardless of their computer literacy, people increasingly will have to use technology, so interfaces need to be as friendly and as usable as possible. One important step may be to provide more opportunities for community-based training to orient people to technology.

Clayton Lewis pointed out that the stakes are high in getting people connected. People who are unable to use technology can have a significantly lower quality of life, an inability to participate in critical activities, and a higher chance of dying in some cases. Some countries have made a societal investment in making sure that people are connected, but the United States has not done that. A major challenge to society is to help people get online so that they do not become second-class citizens in their own country.

The task is complicated, Lewis added, by constant changes in technology. The technologies being used today will not be the same in the future, so the systems people learn in their jobs, for example, will not necessarily be the systems they will use once they are done working. Constant changes in technology raise the stakes, because people will continually need to learn how to use new devices and programs.

Brewer pointed to the substantial amount of work that has been done to support engagement with the health care system as people age, including the work that Lewis has done.

Perlman said that technological connections often have to be as simple as possible so that in some cases people will not even realize they are using the Web. In that way, people with disabilities can focus on the experience—for example, talking with their grandchildren over a video interface—rather than the technology.

Forum member Margaret Campbell, U.S. Department of Education, observed that more needs to be learned about the question of how to get older people and individuals with disabilities online. Equating an 85- or 90-year-old adult with a younger person who has an intellectual disability is not appropriate. Older adults frequently have multiple chronic conditions and impairments such as cognitive deficiencies, visual impairments, hearing impairments, dexterity problems, or generalized frailty, whereas younger people with disabilities typically have one primary disabling condition.

In response to a question about what technologies seniors need, Brewer advocated for standards-based solutions that take a universal design approach. Technological solutions also need to support interoperability with the specialized assistive technologies that some people may need. Clayton advocated the use of technologies that anyone can use, not just older people. Older people with disabilities should be able to participate in the same activities as everyone else. Perlman suggested a long-term view because many of the technologies in use today are decades old. Platforms should be nonproprietary if possible, which will increase interoperability not only for software but also for devices. Standards-based and interoperable platforms also will spur innovation. No one can predict exactly what needs will exist 10 years or 20 years from today. Thus, a platform-based rather than product-based approach can create flexibility and openness.

Forum member Joe Caldwell, National Council on Aging, pointed out that many healthy-aging programs are built around peer-to-peer support among people who have the same chronic

condition. He noted that online health promotion interventions that connect individuals with disabilities and seniors with one another could help address barriers to participating in such programs (for example, lack of transportation, access in rural areas).

GETTING TECHNOLOGY INTO THE HANDS OF CONSUMERS

G.P. Li, Ph.D.
University of California, Irvine

Entrepreneurship will be critical in getting empowering technologies into the hands of consumers, said Li. In the past, the provision of health care has been top-down. It has been led by physicians and other caregivers. But technology will empower individuals in a bottom-up fashion, just as the Internet has done. The producer and consumer become the same person, which is a paradigm shift in health care.

Technology will also forge a convergence among health care, information, communication, and consumer technologies, said Li. It will make medicine preventive, predictive, personalized, and participatory, as well as bring parity to medicine. To realize this potential, technology needs to be affordable, accessible, and portable. Furthermore, it needs to meet the needs of everyone, not just those who are older or have limitations.

The long-term effectiveness of technology depends on motivating users to continue using the technology. Only then will it have a long-term impact on health. Thus, personalizing technology will be critical to long-term use.

Both business and social entrepreneurs are needed, said Li. There are roles for foundations, community centers, fitness centers, and many other organizations. The problem facing the nation is similar to that of energy efficiency. Just as the nation needs to reduce its energy consumption, it needs to improve the quality of life for older Americans.

One option Li suggested is a volunteer government-approval program like the Energy Star program. When an appliance meets energy efficiency standards, it receives a special label. Technologies for wellness, for the home, and for consumers could receive a similar certification. The one problem is that the process for such certification can be too lengthy if done through experiment, as in the case of drug approvals. New ways are needed to engage the consumers of such technologies to make decisions quickly.

Li also observed that many cities have Toys “R” Us stores. Comparable stores should be available to provide empowering technologies for older people with disabilities, he said.

Other Comments

Several workshop participants pointed to the need for future convenings to advance the issues discussed at the workshop. For example, Rory Cooper, University of Pittsburgh, suggested organizing a joint meeting with the President’s Council on Competitiveness, because controlling health care costs for older Americans and people with disabilities is a competitive issue. In addition, the AARP and the American Association of People with Disabilities could work collaboratively with the forum and other bodies. Because about 70 percent of assistive technology is paid for out of pocket, noted Cooper, older adults and people with disabilities have strong viewpoints about what to buy.

A RICH AGENDA

The two cochairs of the forum—Alan M. Jette, director of the Health and Disability Research Institute at Boston University, and John W. Rowe, professor in the Department of Health Policy and Management at the Columbia University Mailman School of Public Health—concluded the workshop by thanking the presenters and other participants and by lauding the rich set of issues raised over the course of the day. Much of the information presented at the forum was new, fresh, and future oriented, said Rowe. As such, added Jette, the workshop was a great success in stimulating future thought and action. "You have provided a tremendous foundation for the forum members to build on," Jette said, "to take what we have learned today and move our work toward action steps to begin to make changes."

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Appendix A

Workshop Agenda

Fostering Independence, Participation, and Healthy Aging Through Technology: A Workshop

December 19, 2012

The Keck Center of The National Academies
Room 100
500 5th Street, NW
Washington, DC 20001

IOM-NRC Forum on Aging, Disability, and Independence

Workshop Objectives

- Focus on adults who by virtue of an inherited/congenital condition, accident, or disease(s) become impaired in their ability to be as independent as possible as they age.
- Provide an overview on how the independence, community integration, and well-being of these individuals can be improved through access to and increased use of technology.
- Examine existing and emerging technologies, with a focus on technologies most likely to be employed ("straddling promise and reality").
- Discuss barriers to deployment and adoption of technologies and reasons for abandonment of technologies already in use.

8:00–8:30 A.M. **REGISTRATION**

8:30–8:40 A.M. **WELCOME AND OPENING REMARKS**

Alan M. Jette, *Forum Co-Chair*
Boston University School of Public Health

John W. Rowe, *Forum Co-Chair*
Columbia University Mailman School of Public Health

8:40–9:15 A.M. **THE PROMISE AND POTENTIAL OF TECHNOLOGY**

Geoff Fernie, *Keynote Speaker*
Toronto Rehabilitation Institute

9:15–9:50 A.M. **VIDEO PRESENTATION AND CONSUMER PERSPECTIVE**

Larry Minnix, LeadingAge
Majd Alwan, LeadingAge
Steve Saling, Leonard Florence Center for Living

9:50–10:05 A.M. **BREAK**

10:05–10:50 A.M. **TECHNOLOGY AND INDEPENDENT LIVING: CAN WE MOVE IDEAS IN THE LABORATORY INTO INNOVATIONS IN THE LIVING ROOM?**

Joseph F. Coughlin, *Keynote Speaker*
AgeLab, Massachusetts Institute of Technology

10:50 A.M.–12:00 P.M. **TECHNOLOGIES TO PROMOTE ACTIVITIES OF DAILY LIVING AND INDEPENDENCE**

Judith Kasper, *Panel Moderator*
Johns Hopkins Bloomberg School of Public Health

Individual Level (Mobility Issues)
Rory Cooper, University of Pittsburgh

Environmental/Systems Level (Smart Homes)
Gregory N. Wellems, Imagine!

Hunter Peckham, *Reactor*
Case Western University

11:35 A.M.–12:00 P.M. **Q&A with Forum Members and Audience**

12:00–12:30 P.M. **LUNCH BREAK**

12:30–1:40 P.M. **TECHNOLOGIES TO PROMOTE COMMUNITY INTEGRATION AND PARTICIPATION: COMMUNITY DESIGN**

Kathy Krepcio, *Panel Moderator*
John J. Heldrich Center for Workforce Development; Rutgers, The State University of New Jersey

New Technologies for Accessible Transportation
Mohammed Yousuf, U.S. Department of Transportation

Workplace Accommodations
Jon Sanford, Georgia Tech

Seth Bravin, *Reactor*
IBM Human Ability and Accessibility Center

1:15–1:40 P.M. **Q&A with Forum Members and Audience**

1:40–2:50 P.M. **TECHNOLOGIES TO PROMOTE COMMUNITY INTEGRATION AND PARTICIPATION: SOCIAL CONNECTEDNESS**

Margaret L. Campbell, *Panel Moderator*
National Institute on Disability and Rehabilitation Research (NIDRR)

Web Accessibility as a Critical Aspect of Person-Centered Supports and Services
Judy Brewer, Web Accessibility Initiative, World Wide Web Consortium; Massachusetts Institute of Technology

Cloud Computing
Clayton Lewis, National Institute on Disability and Rehabilitation Research (NIDRR)

Marc Perlman, *Reactor*
Oracle

2:25–2:50 P.M. **Q&A with Forum Members and Audience**

2:50–3:15 P.M. **BREAK**

3:15–4:45 P.M. **HEALTH MANAGEMENT AND PROMOTION**

René Seidel, *Panel Moderator*
SCAN Foundation

Health Monitoring
Joseph V. Agostini, Aetna

Rehabilitation
Carolee Winstein, University of Southern California

Health Behavior
Timothy Bickmore, Northeastern University

G. P. Li, *Reactor*
University of California, Irvine

4:15–4:45 P.M. **Q&A with Forum Members and Audience**

4:45–5:00 P.M. **CONCLUDING REMARKS**

Alan M. Jette, *Forum Co-Chair*
Boston University School of Public Health

John W. Rowe, *Forum Co-Chair*
Columbia University Mailman School of Public Health

5:00 P.M. **ADJOURN**

Appendix B

Speaker Biographical Sketches

Joseph V. Agostini, M.D., is senior medical director for Aetna Medicare. He has responsibility for medical management strategy, clinical initiatives, and provider collaboration oversight nationally for Aetna Medicare members. Dr. Agostini is a graduate of Yale University and Vanderbilt School of Medicine. He completed postgraduate training at Yale–New Haven Hospital and a fellowship in the Robert Wood Johnson Clinical Scholars Program. He is board certified in internal medicine and geriatric medicine. He was previously on the full-time faculty at Yale School of Medicine in geriatrics. His research interests include aging-related health services research, medication prescribing in older persons, and quality of care for those with multiple chronic conditions.

Majd Alwan, Ph.D., is senior vice president of technology and executive director of the LeadingAge Center for Aging Services Technologies (CAST). Dr. Alwan is a noted researcher and authority on aging-services technologies. He is responsible for creating and leading a network of technology companies, providers, and research institutions focused on technology solutions for an aging society. The network advances the interests of older consumers, caregivers, and providers and fosters opportunities for collaboration between provider organizations, technology companies, and research institutions in exploring product development, testing prototypes, evaluating technology, and deploying technology-enabled care models. Prior to joining CAST, Dr. Alwan served as an assistant professor and the director of the Robotics and Eldercare Technologies Program at the University of Virginia's Medical Automation Research Center. His research interests include passive functional and health assessment, biomedical instrumentation, medical automation, as well as eldercare and assistive technologies.

Timothy Bickmore, Ph.D., is interested in the development and study of relational agents, computer agents designed to build and maintain long-term, social-emotional relationships with people. In order to use the same myriad cues that people use when relating to each other, he builds agents that are capable of emulating face-to-face interaction with people, including the use of hand gestures, facial expressions, and body posture, in addition to speech. These agents are effective for tasks in which long-term interactions and personal relationships are known to be important, such as in education, sales and marketing, and particularly health care. Professor Bickmore has conducted communication studies of health provider–patient interactions to develop new approaches to dialogue planning that can address both the behavioral intervention and the social aspects of the interactions. He has also developed animated agents that can emulate this behavior and use appropriate nonverbal behavior in their simulated conversations with patients. In addition, he has conducted several clinical trials to evaluate the efficacy of the resulting systems.

Seth Bravin, M.B.A., is strategic industries program manager with the IBM Human Ability and Accessibility Center. This center is a recognized world leader in creating technology and business innovations that support human ability and accessibility. In his prior role with IBM, he worked in finance and planning for the Global Public Sector. Before joining IBM, he worked for Booz Allen Hamilton, a management and technology consulting firm, and Dow, Lohnes and Albertson, a corporate law firm. Bravin graduated from Gallaudet University and received his master of business administration degree from Cornell University. He testified before the U.S. Senate about higher education and employment for people with disabilities. He was selected as the Employee of the Year by *Careers and the Disabled* magazine and taught at the Gallaudet Leadership Institute for three summers. He has hosted several technology camps sponsored by IBM for deaf and hard-of-hearing high school students. He currently serves on the board of Lexington School for the Deaf.

Judy Brewer directs the Web Accessibility Initiative (WAI) at the World Wide Web Consortium (W3C). W3C's work on Web accessibility includes ensuring that W3C technologies support accessibility; developing accessibility guidelines for Web content, browsers, media players, and mobile devices; writing tools; developing resources to improve Web accessibility evaluation tools; providing education and outreach on Web accessibility; coordinating with research and development that may impact future accessibility of the Web; and promoting implementation of Web accessibility standards. WAI guidelines include the Web Content Accessibility Guidelines 2.0, which has been adopted by many governments around the world; the Authoring Tool Accessibility Guidelines and User Agent Accessibility Guidelines; and Accessible Rich Internet Applications (WAI-ARIA). Ms. Brewer coordinates accessibility policy and standardization issues for W3C internationally, promoting awareness and implementation of Web accessibility and ensuring effective dialogue among industry, the disability community, accessibility researchers, and government on the development of consensus-based accessibility solutions. She is a principal research scientist at MIT's Computer Science and Artificial Intelligence Laboratory. Ms. Brewer is the recipient of a RESNA (Rehabilitation and Engineering Assistive Technology Society of North America) Certificate of Appreciation for efforts related to assistive technology policy development during national health care reform; an Equality of Access and Opportunity Award from the American Foundation for the Blind for advocacy to increase the accessibility of the Windows 95 operating system; and an Access Advancement Award from the Association of Access Engineering Specialists for efforts related to Web accessibility. She was named in the August 2000 issue of *Internet World* as one of the "Net's Rising Stars." She received the Harry J. Murphy Catalyst Award at the California State University, Northridge (CSUN) 2002 Conference; the Roland Wagner European Award for Computers Assisting People with Special Needs in 2002; the Susan G. Hadden Pioneer Award from the Alliance for Public Technology in 2003; and SXSW's Dewey Winburne Community Service Award in 2012. Prior to joining W3C, Ms. Brewer worked on several U.S.-based initiatives to increase access to mainstream technology for people with disabilities and to improve dialog between industry and the disability community. These initiatives included work on Section 508 of the Workforce Investment Act, Section 255 of the Telecommunications Act, accessibility of the Windows 95 Operating System, and access to durable medical equipment for people with disabilities. Ms. Brewer has a background in management, technical writing, education, applied linguistics, and disability advocacy.

Rory A. Cooper, Ph.D., received B.S. and M.Eng degrees in electrical engineering from California Polytechnic State University, San Luis Obispo, and a Ph.D. degree in electrical and computer engineering with a concentration in bioengineering from University of California, Santa Barbara. He is FISA and Paralyzed Veterans of America (PVA) Chair and distinguished professor in the Department of Rehabilitation Science and Technology, and professor of bioengineering, mechanical engineering, physical medicine and rehabilitation, and orthopedic surgery at the University of Pittsburgh. Dr. Cooper is founding director and Veterans Affairs (VA) senior research career scientist of the Human Engineering Research Laboratories, a VA Rehabilitation Research and Development Center of Excellence in partnership with the University of Pittsburgh. He is also the codirector of the National Science Foundation's Quality of Life Technology Engineering Research Center, a joint effort between the University of Pittsburgh and Carnegie Mellon University. Dr. Cooper has written or cowritten more than 250 peer-reviewed journal publications, and he has more than 10 patents awarded or pending. Dr. Cooper is the author of two books: *Rehabilitation Engineering Applied to Mobility and Manipulation* and *Wheelchair Selection and Configuratio*n. In 1988 he was a bronze medalist in the Paralympic Games, Seoul, Republic of Korea. He was on the steering committee for the 1996 Paralympic Scientific Congress held in Atlanta, Georgia, and the sports scientist for the 2008 U.S. Paralympic Team in Beijing, China. Dr. Cooper, a U.S. Army veteran with a spinal cord injury, is also a director of the Paralyzed Veterans of America Research Foundation. He currently serves as a member of the U.S. Secretary of Veterans Affairs Prosthetics and Special Disability Programs Advisory Committee, the board of directors of Easter Seals, and other national committees and boards. Dr. Cooper was recognized in the *Congressional Record of the United States Congress* on Monday, July 27, 2009, for his contributions to people with disabilities and for his personal example.

Joseph F. Coughlin, Ph.D., is director of the Massachusetts Institute of Technology AgeLab. His research provides insights on how demographic change, technology, social trends, and consumer behavior will converge to drive future innovations in business and government. Based in MIT's Engineering Systems Division, he teaches policy and systems innovation and is author of the online publication *Disruptive Demographics*. He is one of *Fast Company* magazine's "100 Most Creative People in Business" and was named by the *Wall Street Journal* as one of "12 pioneers inventing the future of retirement and how we will all live, work and play tomorrow." Dr. Coughlin is a behavioral sciences fellow of the Gerontological Society of America and a fellow of Switzerland's World Demographics and Ageing Forum, advising and speaking to businesses, governments, and nonprofits worldwide. He has served on numerous advisory boards, including those for British Telecom Health, Daimler, Fidelity Investments, Gallup, Healthways, Nissan, Putnam Investments, Sanofi-Aventis, and Toyota. He was appointed by President Bush to the White House Conference on Aging Advisory Committee. Dr. Coughlin has worked with governments in Asia and the European Union and with the World Economic Forum, the Organisation for Economic Co-operation and Development, and the Council on Foreign Relations on demographic change, technology, and strategic advantage. He has been featured on *ABC News*, the BBC, CBS *Sunday Morning*, CNN, NBC's *Today Show*, and *Dr. Oz* and in *News Asia*, *Economist*, *Financial Times*, *Straits Times*, *New York Times*, *Wall Street Journal*, and other media outlets throughout the world. Prior to MIT he was with EG&G, a Fortune 1000 science and technology firm consulting to business and government worldwide.

Geoff Fernie, BSc, Ph.D., MIMechE, CEng, PEng, CCE, has a primary appointment at the University of Toronto as professor in the Department of Surgery with cross appointments that include the Institute of Biomaterials and Biomedical Engineering, Departments of Mechanical and Industrial Engineering, Physical Therapy, and Occupational Science and Occupational Therapy. He is a professional engineer and institute director for research at Toronto Rehabilitation Institute–University Health Network. Dr. Fernie is recognized as a world leader in the application of engineering to create solutions for problems commonly encountered by people with disabilities. He is the principal investigator on a major infrastructure award from Canada Foundation for Innovation (CFI) which funded the most advanced design, prototyping, and testing facilities for rehabilitation technology and assistive devices in the world. He focuses on the development of technology to help people continue to live in their own homes. He has six commercialized products and four currently in clinical trials and has helped launch three successful companies. He has published more than 120 peer-reviewed journal papers and book chapters and has 17 awarded patents and an additional 11 filings. Dr. Fernie's achievements have been recognized by the Jonas Salk Award, the MEDEC Award, the Mickey Milner Award, and the Queen's Diamond Jubilee Medal, and he has been admitted to the Terry Fox Hall of Fame and the Canadian Academy of Health Sciences.

Clayton Lewis, Ph.D., is professor of computer science and fellow of the Institute of Cognitive Science at the University of Colorado. He is well known for his work (with students and colleagues) on evaluation methods in user interface design, including the thinking aloud and cognitive walkthrough methods. His recent work on technology for people with cognitive disabilities has been presented to the U.S. Access Board Technical Advisory Committee, CSUN, the Rehabilitation Engineering and Assistive technology Society of North America (RESNA), the Association for Computing Machinery ASSETS forum, and other forums, and he has served as scientist in residence at the Coleman Institute for Cognitive Disabilities. He is a member of the CHI Academy, recognizing his contributions to human computer interaction. He is currently on leave from the university, serving as a consultant on cloud computing for the National Institute on Disability and Rehabilitation Research.

G. P. Li, Ph.D., is a professor at the University of California, Irvine (UCI) with appointments in three departments: Electrical Engineering and Computer Science, Chemical Engineering and Materials Science, and Biomedical Engineering. At UCI, he also serves as division director of the California Institute for Telecommunications and Information Technology (Calit2) and director of the Integrated Nanosystems Research Facility in the Henry Samueli School of Engineering. He serves as the National Science Foundations's Integrative Graduate Education and Research Traineeship (IGERT) "LifeChips" director at UCI to promote a new research paradigm that has driven the need for collaborations among researchers from traditionally different backgrounds and cultures, namely, life scientists (biologists, medical researchers) and technologists (physical scientists, nano/micro engineers). LifeChips also represents the fusion of two major industries, the microelectronics industry with the life science industry. Li holds 22 U.S. patents, with an additional 12 patents pending, and has published more than 300 research papers involving microelectronic technologies, microwave circuit design, microelectromechanical systems (MEMS) for communication and biomedical instrumentation applications, and bio-nano-IT technology. During his tenure as a research staff member and manager of the technology group at IBM's T.J. Watson Research Center (1983–1988), Li

worked in the area of very large scal integration technology and led a research/development team to transfer the technology into the marketplace. In 1987 he chaired a committee charged with defining IBM's semiconductor technology roadmap beyond the year 2000. A member of numerous technical committees at professional conferences, Li was chair of the Taiwan VLSI Technology, Circuit, and System Conference in 2006. He also served as chair of the executive committee for electronics manufacturing research and new materials at the University of Southern California. Li received an Outstanding Research Contribution Award from IBM (1987), two Outstanding Engineering Professor awards from UCI (1997 and 2001), the UCI Innovators Award (2005), Best Paper award from the ITC International Telemetering Conference (2005), and Outstanding Asian American and Pacific Islander Community Leaders and Role Models award by the Asian Business Association of Orange County (2009). Li has been involved in several startup companies as a cofounder or member of the technical advisory board. Currently, he also directs TechPortal, a technology business incubator housed at the UCI division of Calit2, which supports and nurtures young companies and university researchers commercializing their technologies. His current research interests focus on developing technologies for efficient energy utilization and consumption and e-health (empowering human health and wellness with IT/communication and sensor/biofeedback technologies).

P. Hunter Peckham, Ph.D., is the Donnell Institute Professor of Biomedical Engineering and Orthopaedics; distinguished university professor; executive director, Institute for Functional Restoration (IFR) at Case Western Reserve University; senior career research scientist and associate director of Technology Transfer, Cleveland FES Center of Excellence, in the Department of Veterans Affairs; and member of the bioscientific staff at Metrohealth Medical Center. The IFR deploys neuroprosthetic interventions into clinical use to restore the functions lost due to spinal cord injury or other paralytic conditions. Under the leadership of Dr. Peckham, the IFR acts as the surrogate corporate partner for the neural technologies that have been demonstrated to be feasible within the research programs. Dr. Peckham is also the principal investigator on the National Institute of Biomedical Imaging and Bioengineering Biomedical Research Partnership Award, which has led to the development of the networked neuroprosthesis. Dr. Peckham's major area of research is in rehabilitation engineering and neuroprostheses. His research effort focuses on functional restoration of the paralyzed upper extremity in individuals with spinal cord injury. He and collaborators developed a number of implantable neural prostheses that use electrical stimulation to control neuromuscular activation. They have implemented procedures to provide control to the upper extremity in individuals with tetraplegia, enabling individuals with central nervous system disability to regain the ability to perform essential activities of daily living. His present efforts concern technology development, expansion of the indications for this technology, and technology transfer. Dr. Peckham is a fellow of the American Institute of Medical and Biological Engineering; a fellow and honorary member of the American Spinal Injury Association; and member of the National Academy of Engineering. He is also a member of numerous professional organizations. Dr. Peckham received the Paul B. Magnuson Award, the highest honor for VA rehabilitation investigators. He received his undergraduate degree in mechanical engineering from Clarkson College of Technology (now Clarkson University), Potsdam, New York, and his M.S. and Ph.D. degrees in biomedical engineering from Case Western Reserve University.

Marc Perlman is global vice president for the health care and life sciences industry at Oracle, responsible for driving strategy and industry solutions across the organization. With more than 29 years in the health care industry, Mr. Perlman brings in-depth experience in working with payers, providers, health and device manufacturers, consumers, and the federal government to improve operational performance, clinical quality, patient safety, and revenue cycle performance. Mr. Perlman joined Oracle from the McKesson Corporation, where during his 13-year tenure he progressed through operational and sales leadership roles in its provider technology solutions, health solutions, and medication safety/automation businesses. Prior to McKesson, he held executive roles with various health care organizations focused on analytics, services, and innovative disease management programs.

Steve Saling was diagnosed with the neurodegenerative condition of ALS, also known as Lou Gehrig's disease, at the age of 38. When given a life expectancy of 2 to 5 years, Saling decided to change the way ALS patients were living their lives. Over the next 3 years, Saling helped create the Steve Saling ALS Residence in Chelsea, Massachusetts. It is the first and only urban model Green House® ALS and multiple sclerosis model in the world. Steve teamed up with visionary chief executive officer Barry Berman of the Chelsea Jewish Foundation (www.chelseajewish.org), and together they designed and built the award-winning Leonard Florence Center for Living (LFCL). The residences are fully automated to provide a level of independence and productivity previously unavailable. Saling set out to prove that ALS does not have to be fatal anymore. His motto is simple yet powerful: "Until medicine proves otherwise, technology IS the cure." Today, 6 years after he was diagnosed with ALS, Saling is living a busy and productive life. In addition to skydiving, sailing, and skiing (here is a link to last summer's skydiving expedition: http://vimeo.com/25932889), Saling goes on outings with his son, gives tours of the center, and writes articles and produces videos about living with ALS. As cofounder of the ALS Residence Initiative, Steve is working to replicate the residences across the country. Recently he arranged a tour of the LFCL for Steve Gleason, the former NFL New Orleans Saints player who was diagnosed with ALS. As a result, a second ALS residence is scheduled to open in New Orleans. Steve's story is one of courage, inspiration and motivation. Please visit his Facebook page at http://www.facebook.com/smoothsaling. Saling continues tirelessly to help individuals with disabilities regain their spirit and zest for living. Saling notes, "My whole life has perfectly prepared me to be right where I am today. I was a very good landscape architect, and I am proud of my professional achievements, but my most important work will be done after I got ALS."

Jon Sanford, M.Arch, is director of the Center for Assistive Technology and Environmental Access and an associate professor of industrial design in the College of Architecture at Georgia Tech. He is also a research architect at the Rehabilitation Research and Development Center at the Atlanta Veterans Affairs Medical Center. Mr. Sanford received both B.S. and M.Arch. degrees from Georgia Tech and is one of the few architecturally trained researchers engaged in accessible and universal design. He has been actively involved in research and development related to the accessibility and usability of products, technologies, and environments for the past 25 years and was one of the authors of the *Principles of Universal Design*. He is the codirector of the NIDRR-funded Rehabilitation Engineering Research Center on Workplace Accommodations, and he recently received a 5-year NIDRR DRRP award to examine the effects of universal design on workplace participation of employees with disabilities. He currently

teaches a course in universal design in the Architecture and Industrial Design Programs and serves as an academic advisor to both master of industrial design and Ph.D. students. He has almost 250 peer-reviewed presentations, publications, and book chapters and has recently published the book *Design for the Ages: Universal Design as a Rehabilitation Strategy*.

Greg Wellems began his career 25 years ago in direct care supports. For the last 20 years he has worked as the chief operating officer of Imagine!, a service provider located in Boulder, Colorado. Mr. Wellems is responsible for the development of many innovative programs designed to better meet the needs of persons with disabilities and has created software programs that are being used by human service providers across the nation. His current focus is on developing and incorporating technology to improve supports for individuals with cognitive disabilities. This focus has resulted in the development of the two SmartHomes, which serve as a model for the future of care for individuals with cognitive disabilities and related conditions. Mr. Wellems also works as a consultant, assisting organizations to implement technology, and he serves as a member of the board of directors for the American Network of Community Options and Resources.

Carolee J. Winstein, Ph.D., PT, FAPTA, runs an interdisciplinary research program focused on understanding control, rehabilitation, and recovery of goal-directed movements that emerge from a dynamic brain-behavior system in brain-damaged conditions. With funding from the National Institutes of Health (NIH), she and her team are leading a multisite Phase III randomized controlled trial—ICARE (Interdisciplinary Comprehensive Arm Recovery Evaluation) stroke initiative—to improve outpatient therapy for arm weakness after stroke. With funding from the Foundation for Physical Therapy, she led the first physical therapy clinical research network, PTClinResNet, which supported clinical research on the effectiveness of task-specific/muscle-specific training to enhance muscle performance and functional activities across four disability groups: adult spinal cord injury, cerebral palsy in children, adult stroke, and low back pain. In 2008, with funding from the NIDRR and Department of Education, she and her colleagues at USC and Rancho Los Amigos National Rehabilitation Hospital established a Rehabilitation Engineering Research Center (RERC) to study the challenges of growing older with and into disabilities and the positive effects that new technologies can have on independence, health, and quality of life. With funding from the National Institute of Child Health and Human Development and in collaboration with colleagues at the University of Southern California, Winstein recently launched a new development-of-concept trial, Optimizing Dosage of Rehabilitation after Stroke (DOSE), to ultimately determine prospectively the dose of therapy that maximizes the efficacy of treatment, that is, determine the smallest effective dose for individual patients.

Mohammed Yousuf, M.S., is a research engineer in the Office of Operations Research and Development at the Federal Highway Administration (FHWA) and, under FHWA's Exploratory Advanced Research Program, is leading research on new technology solutions for wayfinding and navigation guidance for people with vision impairments and other disabilities. As a member of the GeoAccess Challenge Team, Yousuf worked on the White House report *Data-Enabled Travel: How Geo-Data Can Support Inclusive Transportation, Tourism, and Navigation through Communities*. Prior to joining FHWA, he worked at General Motors and Chrysler Group in vehicle product development, telematics and infotainment, and advanced service diagnostics. He

has a B.S. in electronics and communication engineering from Osmania University in India and an M.S. in computer engineering from Wayne State University in Michigan.