Center for Technology and Aging

Assistive Technologies for Functional Improvement

Technology Review
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Introduction

The Center for Technology and Aging (techandaging.org) supports more rapid adoption and diffusion of technologies that enhance independence and improve home and community-based care for older adults. Technology reviews, such as this one on assistive technology, inform and guide the Center's priorities and initiatives, and advance its mission to serve as an independent, non-profit resource for improving the quality and cost-effectiveness of long-term care services. Assistive technologies are one of the Center's potential technology focus areas for grants, research, and public policy involvement.

This technology review focuses on assistive technologies that help older adults with physical, sensory, and communications challenges to maintain independence and live safely at home or in other community-based settings. The paper begins by describing the prevalence and types of disabilities that are experienced by older adults (65 years and older). The paper then describes four types of challenges that may be mitigated by assistive technologies: 1) physical or mobility challenges, including falls, 2) hearing impairment, 3) vision impairment, and 4) communication and information-access challenges. The review includes examples of devices and products that address each of these challenges, but it is not meant to be exhaustive. The paper closes with a discussion of adoption and diffusion challenges, and legislation that can address these challenges.

Overview

In the following, *assistive technology* primarily refers to technologies or devices that are used to maintain or improve a person's ability to carry out daily tasks. Assistive technologies help persons with disabilities perform tasks by compensating for physical, sensory, and cognitive impairments, and by promoting self-management and independence. Assistive technologies can be as simple as an amplification device to address hearing loss, a cane to help with balance and support, or a device that improves sight. In severe cases, assistive technologies "make the difference between being able to live independently and having to get long-term nursing or home-healthcare."[1]

With an upsurge in longevity, a growing population of older adults and an association between age and disability, the need for assistive technologies is expected to increase dramatically. Approximately 23% of adults aged 45-64 years have some form of disability; for those 65 to 69 years old, the likelihood of being affected by a disability nearly doubles to 45%. Approximately 74% of adults aged 80 years old and over have a disability.[2]

Nearly 14 million older adults aged 65 and older (42%) report having one or more disabilities. A physical disability is most common (29%), followed by difficulty going out (20%) and sensory (14%) and mental (11%) disabilities.[2]

Fig 1: Prevalence and Types of Disabilities Experienced By Adults Aged 65 and Older[2]

	Number (millions)	Percent
Total Older Adults	**33.3**	**100%**
With any disability	**14.0**	**42%**
Sensory	4.7	14%
Physical	9.5	29%
Mental	3.6	11%
Self-care	3.2	10%
Difficulty going out	8.8	20%

Assistive and rehabilitative technologies promote independence by enabling individuals with disabilities to complete basic tasks of daily living, which can be assessed by the ability to perform activities of daily living (ADLs) and instrumental activities of daily living (IADLs). ADLs include everyday tasks such as dressing, daily hygienic practices, using the restroom, and transferring

from one location to another. IADLs include complex activities such as balancing checkbooks, driving, preparing meals, doing housework and managing medication.[3]

According to a recent study, approximately one in four community-resident Medicare beneficiaries over age 65 had difficulty in performing one or more ADLs. An additional 15% reported difficulties with IADLs.[4] Older adults' ability to maintain their independence is connected to their ability to perform ADLs and IADLs without requiring a great deal of assistance.

Because assistive technologies may reduce reliance on informal care, decrease functional decline, and lower health-related costs, they can benefit caregivers and society at large, as well as persons with disabilities.

- According to a recent survey of unpaid caregivers, 40% had obtained assistive technology on behalf of the people they care for in order to "make things easier."
- A randomized controlled trial found that the rate of functional decline was slower among users of assistive technologies and environmental interventions compared to their counterparts who received "usual care practices."[5]
- The same study found that systematically providing and promoting the use of assistive technologies and environmental interventions could reduce formal caregiver costs.[5]
- It is also noteworthy that many informal caregivers are over the age 65 and have one or more disabilities.
- Mobility aids help reduce risk of falling in older adults. Falls significantly contribute to disability in older adults. Moreover, a majority of nonfatal injuries and hospital admissions for trauma among older adults are attributable to falls.[6]

Various systems are working to expand the use of assistive technologies. For instance, the Assistive Technology Network, a system created by the California Foundation for Independent Living Centers (CFILC), is working to expand accessibility of resources and technology that will help decrease dependence, improve productivity and help individuals contribute to the society.[7]

Improving Physical Function and Reducing Falls

Fall-related injuries are a large and growing problem for older adults, families, and society.

- Over a third of adults over age 65 fall each year in the United States.[8, 9]
- Falls are associated with morbidity, mortality and functional impairment which increase nursing home admissions.[10]
- According to two American studies, falls and lack of balance are a major contributing factor in 40% of nursing home admissions.
- Falls are the leading cause of injury in persons over age 65.[11] As a result, most hospital admissions in the older adult population are connected to falls.
- The economic costs of treating fall-related injuries will rise substantially as the "baby boomer" population reaches retirement age.

Fear of falling in older adults also has unfortunate consequences, including a toxic combination of more limited physical activity, decreased social interaction, and increased dependence.[12] Aging invariably leads to muscle weakness which in turn affects the balance and posture of an older adult. Additionally, biological risk factors such as chronic health conditions, loss of sensation and deterioration of vision perpetually increase the risk of falling.[13] Behavioral risk factors such as lack of physical activity and a lack of comprehension of the side effects of medications also increase the risk of falling.

Fall detection technologies actively or passively evaluate whether a fall has taken place and alert others that an individual has fallen. The primary goals of fall detection technologies are to distinguish falls from activities of daily living (ADL) and then contact authorities who can quickly assist the individual. Fall detection systems can be active, passive or a combination and include personal emergency response systems (PERS) and passive sensors. Active systems, such as PERS, are devices that users must activate to obtain assistance, most commonly by pushing a button or pulling a cord. Passive systems involve the use of sensors to continuously monitor movement, while utilizing specific algorithms and alert systems to inform caregivers and others of potential falls. Users do not need to activate passive systems as they automatically detect a fall and contact help. Motion and pressure sensors can be placed around the living facility on walls, ceilings, floorboards, and furniture while location and position sensors, like accelerometers and gyroscopes, can be placed on older adults themselves. Some passive systems contain a back-up active system where users can activate the device for assistance.

Many types of PERS require patients to activate an alarm for assistance. Devices can be stationary (pull cords and emergency buttons) or portable (necklaces or bracelets). After

activation, the device communicates with a transmitter, which relays the information, often through the phone line, to a third-party vendor at a monitoring center. Here, third parties assess the situation, contact appropriate parties for further assistance, and often initiate audio communication with the older adult through the telephone or another portable or fixed transmitter device. Users typically pay for the monitoring equipment as well as a monthly service plan for access to third-party support. User activation, especially with stationary PERS, can cause difficulties if an older adult falls and is not within reach of the device. Portable systems can also pose a challenge to activate if an individual falls or becomes incapacitated. Portable PERS also require that the older adult always wear the device. Dementia or other cognitive ailments may cause the user to forget to wear or activate the device. Bulky, less attractive systems also discourage the user from wearing it, as they may find the device uncomfortable or embarrassing.

Passive fall detection technologies utilize a variety of sensors, including motion and pressure sensors, accelerometers, and gyroscopes to monitor location, position, immobility, speed of motion, and distance covered. Passive sensor technologies automatically detect falls and promptly alert the appropriate parties. Different types of sensors can be used to detect movement, including motion sensors affixed to the walls of users' homes, accelerometers and gyroscopes attached to the user, and pressure sensors in the floorboards underneath carpet. Algorithms are utilized to set thresholds for alert notification tailored to each older adult by monitoring patterns of movement and behavior. For example, a data pattern can assist with detecting urinary tract infections through frequency of bathroom visits at night or throughout the day. Such technology also can signal that individuals may need to move to a higher acuity setting or that they should consider using mobility assistive technologies if patterns change and mobility begins to deteriorate. System dashboards integrate individual and multiple user data in an easy-to-monitor format. Dashboards can stratify alert notifications based on severity, which can be particularly valuable for assisted or independent living communities that monitor several people at once.

Technologies that predict the likelihood of falling by observing pressure distribution and movement patterns are still in the development stage. For instance, MIT researchers are developing the iShoe technology, a device that monitors balance by analyzing the pressure distribution of a person's gait.[14]

Mobility impairments are a major contributor to decreased quality of life, as they increase dependence on caretakers, limit social interaction, and increase risk of health problems related to lack of exercise. Mobility assistance technologies, such as power wheel chairs, wheelchair lifts, posture optimization devices, breathing assistive devices and neuro-protheses, help older adults

cope with the loss of motor function and help them get around without requiring assistance from a caregiver. Mobility aids also offer a safe way for older adults to gradually initiate muscle movement and reduce immobility. The table below provides examples of mobility devices.

Figure 2: Examples of Mobility Assistance Devices

Mobility devices	Description
Alarm with Fixed or Portable Receiver and Transmitter Philips Lifeline, MedicalAlarm.com	Personal Emergency Response Systems require older adults to activate a call button, which can either be stationary in a room (Pull cords, stationary emergency buttons) or portable worn by the user (Emergency necklaces, bracelets). Some devices activate third party audio communication with the patient to address the situation and can contact the appropriate parties for further assistance.
Motion Sensors and Pressure Sensors with Algorithms GE's QuietCare, myhalo, GrandCare Systems	Motion sensor units are placed around the user's house or apartment on the walls or on the ground. Sensors continuously track user's motion. Preset algorithms determine whether user has fallen by analyzing immobility where users remain still in one area for longer than the allotted time. Software alerts third party or caregiver to potential fall.
Boomer medgadget.com	A concept of a walker that enables users to safely maneuver up and down the stairs. Uses an "electric linear actuator" that provides stable support at the base of the rear wheels.[15]
Portable Fall Alert for Cane, Walker or Wheelchair assistivetechnologyservices.com	Attaches to a cane, walker or wheelchair. When a mobility aid (cane, walker or wheelchair) falls past a 30 degree angle, the fall detection device will emit an alarm within 15 seconds. Also has a "call-for help" button.
Deluxe Mobility Support Pole-Grab Bar assistivetechnologyservices.com	A grab bar that is spring-loaded, making it movable. The lack of permanent attachment allows the system to offer support while going to the bathroom, showering and transferring from a mobility device such as a wheelchair to a bed
Lighted Cane assistivetechnologyservices.com	A xenon bulb is installed inside the cane. The light covers a 3' to 4.5' diameter.[16] The lighted cane helps prevent falls in older adults by shedding light on dark paths.

More exotic mobility devices include "exoskeletons" that are worn to increase mobility and strength. Examples that are in the early stages of commercialization or late stages of development include HAL, or Hybrid Assistive Limb, a powered exoskeleton suit developed by

Tsukuba University of Japan. Stride Management Assist and Bodyweight Support Assist are exoskeletons in development at Honda Motors. The Stride Management Assist straps around one's waist and thighs then subtly nudges your legs forward with each step. The Bodyweight Support Assist is a device with shoes that are connected through a series of articulated joints and bars to a saddle that, when turned on, supports the wearer's weight and exerts more force as the wearer bends down or bends their legs during activities such as climbing stairs. [17]

Enhancing Hearing in Older Adults

Hearing loss is a common condition that affects many older adults, but only 38% of adults over the age of 70 years have had their hearing checked.[18] Approximately one-third of Americans between the ages of 65 and 74, and nearly half of those 75 and older, have experienced hearing loss.[18] Some people lose their hearing gradually as they age, a condition known as presbycusis. Age-related hearing loss can occur due to changes in the inner ear, auditory nerve, middle ear, or outer ear. Loud noises that disrupt the ear, severe injury to the head, and ear infections can also cause presbycucsis.[18]

Hearing aids address hearing loss and are critical in enabling older adults to communicate, maintain their independence, and participate in and contribute to the community. Electronic capsules worn behind the listener's ear amplify sound making it easier for the person experiencing hearing loss to communicate. The miniature system relies on three basic parts: a microphone, amplifier and speaker. Sound is received through the microphone and converted to electrical signals which are sent to the amplifier. The amplifier in turn magnifies the electrical signals and sends them to the inner ear through the speaker.

Hearing aids are divided into three basic styles[19]:

1. *Behind-the-ear (BTE) hearing aids* consist of a hard plastic case that is worn behind the ear and connected to a fitted ear-mold that delivers the sound to the ear. BTE aids are appropriate for people with mild to severe hearing loss.
2. *In-the-ear(ITE) hearing aids* contain a small case holding the electronic features which fit inside the outer ear. ITE hearing aids include additional features such as the telecoil, a magnetic coil that does not require a microphone because it can receive sound through the circuitry of the hearing aid. They are used for mild to severe hearing loss.
3. *Canal hearing aids* are further sub-categorized into in-the-canal (ITC), which are fitted to a person's ear canal and the completely-in-canal (CIC) hearing aids which are hidden in the ear canal. Their small size limits functionality for people with profound hearing loss, hence they are appropriate for mild to moderately severe hearing loss.

Assistive listening devices help overcome deterioration of hearing senses by enhancing hearing in noisy environments.[20] Examples of assistive listening devices can be seen in the next table.

Fig 3: Examples of Assistive Listening Devices[20]

System	Description	Best use
Personal frequency modulation (FM) systems	▪ Similar to miniature radio stations operating on special frequencies assigned by the Federal Communications Commission. ▪ Includes a transmitter microphone which is used by the speaker and a receiver which is used by the listener. ▪ Sound is transmitted to the hearing aid through a direct audio input or a looped cord worn around the neck.	▪ Can be used in a restaurant, senior center, a classroom lecture, a meeting
Infrared systems	▪ Transmit sound using infrared light waves. ▪ The system transmits the signal to the listener's receiver which can be adjusted to the desired volume	▪ Used with TV sets or in theaters.
Induction loop systems	▪ Permanently installed and connected to a microphone used by a speaker. ▪ As the speaker talks into the microphone, a current is created in the wire which in-turn creates an electromagnetic field in the room. The hearing aid telecoil picks up the signal and allows the listener to hear the conversation.	▪ Particularly useful in a large setting
One-to-one communicators	▪ Amplify the sound and directly deliver it to the hearing aid. ▪ One-to-one communicators are useful when an individual wants to hear one person, for instance, while driving in a car a person can speak into the microphone and the sound will de delivered to the hearing aid	▪ Often used in a setting where the user wants to converse directly with one individual

Selecting, acquiring, and using a hearing assist system is usually a four-step process that includes: 1) examination of needs and conduction of a practical evaluation analyzing the impact of the provision of the assistive technology 2) training for the older adult and the caretakers 3) therapies and interventions associated with rehabilitation and education programs 4) selection, customization, application, maintenance and replacement services.[20]

Improving Vision in Older Adults

Aging contributes to a reduction in visual acuity which can lead to an increase in functional dependence.[21] Vision impairments limit the capabilities of older adults and increase the risk of falling. The table below describes example visual assistive devices that help older adults perform daily tasks with minimal assistance.

Fig 4: Examples of Visual Assistive Technologies

Device	Description
JAWS freedomscientific.com	A screen reader for persons with visual impairment that works with any personal computer. JAWS uses speech synthesizer software and the computer's sound card to relay information to the user.
Topaz freedomscientific.com	A video magnifier that enlarges small details and displays them on a screen. Topaz is useful for reading medication labels and care instructions.
Amplified Big Button Quick Dial Picture Phone http://assistivetechnologyservices.com	A phone with enlarged numbers to make it easier for people with visual impairments to make phone calls. Additionally, it allows users to download photos of their loved ones on the speed dial slots. Users press a picture of a loved one and they are automatically connected.

Improving the Ability to Communicate and Access Information

Communication devices enable older adults to converse with ease by sending and receiving verbal or written messages. For example, a telephone amplifier permits the older adult to communicate efficiently with the person on the other line. Technologies like the Accessaphone Total Conversation, a computer-based text telephone and videophone, are specifically designed for individuals with a spectrum of disabilities ranging from hearing impairments to cognitive disabilities. Users of the system can also text in real time or use its voice recognition capabilities.[3]

Research indicates that there is a need to 'bridge the gap' between older adults and the Internet.[22] Various programs help older adults access the internet more easily through special software and modified hardware. For example, an instant captioning system designed for use by individuals who are hard of hearing, makes it possible for users to receive live captioning of personal conversations and meetings. Such systems also provide a printed transcript of conversations.[23] Additionally, modified computers can offer individualized support by collecting specific information about the user and storing it within the user model of an adaptive system.[24] For instance, a computer with a Computer Aided Internet Navigation (CAIN) can select information according to the user's needs and thereby increase the effectiveness of Internet use.[24, 25]

Challenges Hindering Adoption of Assistive Technologies

Many assistive technologies are available, but they are often underutilized. Several obstacles hinder the adoption of assistive technologies. These include consumer-related issues, such as the challenge of paying for assistive technologies; lack of awareness about how assistive technologies can improve functioning and quality of life; and, reluctance to use assistive technologies because of the stigma that is associates with their use.

Paying for assistive technologies is one of the major barriers to adoption. Medicare (Part B) will cover most of the costs of technologies that help mitigate mobility challenges, e.g., wheelchairs and walkers, if a doctor will certify that a patient meets certain conditions. But traditional Medicare does not cover the costs of many other assistive technologies, including hearing aids and certain devices that help with vision impairment. Medicare also does not cover the costs of home safety devices, such as grab bars, because they are considered convenience items. Out-of-pocket payment can be difficult for many older adults. According to the National Council on Aging, nearly a third of older adults are economically insecure, i.e., living at or below 200% of the federal poverty threshold.[26]

Furthermore, there is a lack of awareness about the high incidence and impact of certain impairments in older adults. For example, many are not aware of the high prevalence of hearing impairment among older adults and the physical and emotional impact it has on them.[27] Many organizations sponsor awareness-raising initiatives regarding disability and disability assistance, but these tend to focus on younger people with disabilities even though disabilities are much more prevalent in among older people.

In addition to lack of awareness, some older adults hesitate to use assistive technologies because of what they symbolize for them, e.g., they believe an assistive device might attract unwanted attention to their advancing age or loss of functioning. Community outreach campaigns should have the dual objectives of addressing lack of awareness regarding the benefits of assistive technologies and common perceptions that are associated with use of assistive technologies.

Assistive Technology Legislation

A myriad of federal and state policies have been introduced to address some of the challenges to assistive technology adoption. For example, Congress enacted the Assistive Technology Act of 1998, also known as the Tech Act, in 1991. The Tech Act supports states and US territories in developing comprehensive programs that will assist persons with disabilities.[28] Assistive technology programs must:[29]

1. Increase awareness about availability and benefits of assistive technologies and services,
2. Collaborate with other agencies to improve access to assistive technologies and services,
3. Offer technical assistance and training,
4. Support outreach activities that help persons with disabilities learn about and use assistive technologies and services.

Under the Tech Act, federal and state programs collaborate and offer alternative financing options to people who need to purchase assistive technologies.[30]

In 2004, the House amended the Tech Act and introduced the *Improving Access to Assistive Technology for Individuals with Disabilities Act of 2004.* The modified Tech Act of 2004 supports the continuance of the Assistive Technology Act Programs and shifts from establishing systems to directly working with and assisting persons with disabilities.[31]

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