The Future of Disability in America

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Assistive and Mainstream Technologies for People with Disabilities

As she nears her 70th birthday, Ms. G has increasingly severe arthritis in her hands. She is feeling more and more restricted in her everyday life as daily tasks have become difficult or painful and many products—from the kitchen blender to the little pencils for filling out election ballots—have become hard or impossible for her to use. Recently, during an urgent visit to her physician's office after she sliced her hand with a kitchen knife, she had to see the practice's new partner. She explained that the knife had slipped because it was hard for her to grasp it firmly. The doctor asked whether she had heard of the knives and other ordinary household tools that are designed to be easier—and sometimes safer—for everyone to use. Did she have a computer so she could find out more from groups that had practical advice about technologies and other strategies for people with arthritis? Ms. G said she did. The doctor jotted down a note for her and added "You should check out these two web sites for information about equipment and other Internet resources for people with arthritis and other conditions. Unfortunately, though, you can't buy your own voting equipment."

As this story illustrates, people with conditions such as arthritis may encounter the myriad technologies of modern life in somewhat different ways than people without disabilities. Doorknobs, kitchen tools, or shirt buttons that do not produce a second thought for most people can become obstacles for someone with arthritis. In turn, a lever door handle substituted for a doorknob may be a significant aid to that individual—and also be welcomed by many others, such as parents juggling packages and children. A simple buttonhook device, although not useful to most people, can assist someone who finds it difficult to manipulate buttons. Thus, although certain technologies create obstacles to independence for people with disabilities, other technologies—some of which are designed to accommodate impairments and some of which are designed for general use—provide the means to eliminate or overcome environmental barriers. These helpful technologies may work by augmenting individual abilities (e.g., with glasses or hearing aids), by changing the general environment (e.g., with lever door handles or "talking" elevators), or by some combination of these two types of changes (e.g., with computer screen readers).

Given the projected large increase over the next 30 years in the numbers Americans at the highest risk for disability, as discussed in Chapter 1, designing technologies today for an accessible tomorrow should be a national priority. Otherwise, people who want to minimize the need for personal assistance from family members or others, who want to avoid institutional care, who want or need to work up to and beyond traditional retirement age, or who have talents to volunteer in society will face avoidable barriers that will diminish their independence and role in community life. Accessible technologies are also a matter of equity for people with disabilities, regardless of age. One of the goals of *Healthy People 2010* is a reduction in the proportion of people with disabilities who report that they do not have the assistive devices and technologies that they need (DHHS, 2001; see also DHHS [undated]).

Since the publication of the 1991 Institute of Medicine (IOM) report *Disability in America*, the world of assistive technologies has changed significantly in a number of areas. Perhaps the most dramatic advances involve the expanded communication options that have accompanied the improvement and widespread adoption of personal computers for use in homes, schools, and workplaces. Spurred in part by federal policy incentives and requirements, industry has developed a range of software and hardware options that make it easier for people with vision, hearing, speech, and other impairments to communicate and, more generally, take advantage of electronic and information technologies. In many cases, these options have moved into the realm of general use and availability. For example, people who do not have vision or hearing loss may find technologies like voice recognition software valuable for business or personal applications. Prosthetics technology is another area of remarkable innovation, with research on the neurological control of devices resulting in, for example, prosthetic arms that people can move by thinking about what they want to do (Murugappan, 2006).

Research suggests that assistive technologies are playing important and increasing roles in the lives of people with disabilities (see, e.g., Russell et al. [1997], Carlson and Ehrlich [2005], Spillman and Black [2005a], and Freedman et al. [2006]). For example, using data from the 1980, 1990, and 1994 National Health Interview Surveys, Russell and colleagues (1997) concluded that the rate of use of mobility assistive technology increased between 1980 and 1994 and that the rate of increase was greater than would have been expected on the basis of the growth in the size of the population and changes in the age composition of the population. A more recent analysis by Spillman (2004), which examined data from the National Long-Term Care Survey (for the years 1984, 1989, 1994, and 1999), found that the steadily increasing use of technology was associated with downward trends in the reported rates of disability among people age 65 and

over. Other research, discussed later in this chapter, suggests that assistive technologies may substitute for or supplement personal care. Surveys also report considerable unmet needs for assistive technologies, often related to funding problems (Carlson and Ehrlich, 2005).

Findings such as those just cited suggest that the greater availability and use of assistive technologies could help the nation prepare for a future characterized by a growing older population and a shrinking proportion of younger people available to provide personal care. The increased availability of accessible general use technologies is also important.

Chapter 6 pointed out that people with disabilities encounter technology barriers in many environments, including health care. As surprising as it may seem, individuals with mobility limitations and other impairments may find that examination tables, hospital beds, weight scales, imaging devices, and other mainstream medical products are, to various degrees, inaccessible (see, e.g., Iezzoni and O'Day [2006] and Kailes [2006]). Chapter 6 urged the stronger implementation of federal antidiscrimination policies and the provision of better guidance to health care providers about what is expected of them in providing accessible environments.

Many kinds of technologies, such as medical equipment, voting machines, and buses, cannot be purchased or selected individually by consumers and are, in a certain sense, public goods even when they are privately owned. Their development and accessibility often depend on policies that require or encourage public and private organizations to make environments, services, and products more accessible. Other public policies tackle environmental barriers by encouraging consumer awareness of assistive and accessible products or by helping people purchase or otherwise obtain such products. Yet other policies promote research and development to make all sorts of technologies more usable and accessible to people with different abilities.

This chapter examines the role of assistive and mainstream technologies in increasing independence and extending the participation in society of people with disabilities. It also considers how technologies may act as barriers. Many of the topics discussed are themselves worthy of evaluation in separate reports, so the committee's review has necessarily been limited in scope and depth. The chapter begins with definitions of assistive technology, mainstream technology, and universal design. It then briefly reviews public policies affecting the availability of assistive and accessible technologies, summarizes information on the use of assistive technologies, discusses obstacles to the development of better products and the effective use of existing products, and highlights how mainstream technologies can limit or promote independence and community participation. The chapter concludes with recommendations.

TYPES OF TECHNOLOGIES USED OR ENCOUNTERED BY PEOPLE WITH DISABILITIES

Though coming from quite different histories, the purpose of universal design and assistive technology is the same: to reduce the physical and attitudinal barriers between people with and without disabilities.

Story et al. (1998, p. 11)

The intersection between technology and disability is a complex topic for a number of reasons. As noted earlier, technology can be a barrier or a means to independence and participation in the community. For some people, technologies, such as mechanical ventilators, allow life itself—as long as systems are in place to protect the users when natural disasters or other events disrupt electrical power, caregiving arrangements, and other essential services.

As the term is used in this chapter, *technology* generally refers to equipment, devices, and software rather than to medications (e.g., drugs to control the potentially disabling effects of epilepsy), procedures (e.g., physical therapy techniques to restore function), administrative systems (e.g., rules and implementing mechanisms for determining eligibility for disability income benefits), or a body of knowledge (e.g., rehabilitation medicine). In other contexts, the term may be used much more comprehensively to refer to some or all these additional areas.

Assistive technologies and general use or mainstream technologies, as defined below, may serve similar or quite different purposes in people's lives. Whether a technology is assistive or mainstream may affect how people acquire the technology. For example, certain assistive technologies, such as prostheses, require a physician's prescription and expert training in safe and effective use. The distinction may also affect what health plans pay for, as discussed in Chapter 9. In addition, for any given product category, a mainstream or general use technology is likely to have larger prospective markets and thus may be more likely than an assistive technology to attract private-sector innovation and investment without government incentives or rules.

Assistive Technology Defined

The Technology-Related Assistance for Individuals with Disabilities Act of 1988 and the Assistive Technology Act of 1998, which replaced the 1988 legislation, define an *assistive technology device* as "[a]ny item, piece of equipment, or product system, whether acquired commercially, modified,

or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities" (29 U.S.C. 3002).[1] This policy definition is extremely broad and can be interpreted to cover a very large range of products—such as Velcro and microwave ovens—that are useful to people with disabilities but that are not specifically designed or adapted to assist them.

The broad legislative language intentionally permitted the information and funding programs created by the legislation to cover general use or mainstream products if, for a given individual, such a product worked as well as or better than a specially designed product. Nonetheless, as noted in a report developed for the American Academy of Physical Medicine and Rehabilitation and the Foundation for Physical Medicine and Rehabilitation, "a health plan or program could never include coverage [for assistive technology as defined in the Act] . . . because the benefit would be completely open-ended" (AAPM&R/The Foundation for PM&R, 2003, p. 9). For similar reasons, most discussions of assistive technology, at least implicitly, focus more specifically on items "*designed for* and used by individuals with the *intent* of eliminating, ameliorating, or compensating for" individual functional limitations (OTA, 1982, p. 51, emphasis added).[2]

Environmental modifications, for example, the widening of a bathroom doorway, are not explicitly covered by the Assistive Technology Act, although equipment (e.g., grab bars) installed during modifications is included. Building modifications are sometimes referred to as "fixed assistive technology," not all of which involves equipment installations (see, e.g., Tinker et al. [2004]).

Assistive technologies can be subdivided to distinguish many kinds of products. For example, *personal assistive devices*—such as canes, scooters, hearing aids, and magnifying glasses—act, essentially, as extensions of a person's physical capacities. They often move with the person from place to place. *Adaptive assistive devices* make an inaccessible mainstream or general use device usable by a person with a disability, although usually at additional cost. One example is the computer screen reader, which allows people with low vision to hear what is shown on a computer screen, for

[1]The committee recognizes that all technologies—scissors, wheelchairs, or computers—are assistive in some sense, that is, are tools to serve some human purpose.

[2]The statutory definition of *assistive technology* could be interpreted to include medications (as an "item"), as well as an array of implanted medical devices, such as cardiac pacemakers, orthopedic rods and plates, electronic neurostimulators, artificial joints, and catheters. Although some implanted devices and certain medications may improve functional capabilities, such as the ability to walk, bend, or reach, this report—consistent with most reports consulted by the committee—generally excludes both implanted devices and medications from the definition of assistive technology.

example, text documents. To operate effectively, computer screen readers require appropriate design of what appears on the screen (e.g., text labels for graphics or photos) (Tedeschi, 2006; see also Vascellaro [2006] and http://www.w3.org). Other examples of adaptive assistive technologies are the hand controls that operate braking and acceleration systems for automobiles.

Certain assistive technologies qualify as *durable medical equipment* under the Medicare statute and regulations. That is, they can withstand repeated use, are primarily and customarily used to serve medical purposes, are generally not useful to individuals in the absence of an illness or injury, and are appropriate for use in the home (42 CFR 414.202). The Medicare statute also mentions certain other categories of assistive products, such as prosthetics and orthotics. In general, insurance plans do not cover assistive technologies, as broadly defined by the Assistive Technology Act. (See Chapter 9 for a discussion of financing for assistive technologies under Medicare, Medicaid, private health plans, and other programs.) In some situations, health plans may pay for a more expensive assistive technology when a less expensive mainstream technology would serve as well.[3]

For children, assistive devices include adapted or specially designed toys that not only are entertaining and usable but that also make a contribution to their physical and emotional development (see, e.g., Robitaille [2001]). Continued implementation of the Individuals with Disabilities Education Act has focused attention on a range of educational assistive technologies for children with learning and other disabilities (see Chapters 4 and 9). Some of these technologies may also benefit adults with learning or cognitive limitations, increasing their ability to live independently, work, and otherwise participate more fully in community life.

Examples of cognitive assistive technologies include visual or auditory prompting devices that provide simple cues to help people perform a task (e.g., prepare food) or remember things that they need to do (e.g., take medications). Other examples include alarm devices that help warn caregivers that someone with dementia or some other cognitive condition may be in danger, tracking devices that use Global Positioning System technology to determine the location of an individual, and simplified versions of e-mail.

In addition, although they may be financially out of reach for many potential beneficiaries, a range of new assistive technologies are being developed to take advantage of advances in electronics and computing power

[3]Health plans with case management or similar programs or policies will sometimes waive usual policy limitations and pay for a mainstream product for an individual when it is clear that the product will perform at least as well as a specialized assistive product and will be less costly. See NHATP (2001) for an extensive discussion of how consumers can use cost-effectiveness arguments to persuade health plans to pay for technologies that are not normally covered; see also RESNA (2002).

that have stimulated innovation throughout the economy. Examples of these technologies include communications devices based on the tracking of individual eye movement (e.g., for people with severe speech and movement impairments because of a stroke), complex prosthetic devices that respond to neural impulses, and stair-climbing wheelchairs. As with all technologies, individual and environmental circumstances will influence the usefulness and the availability of specific technologies.

Mainstream Technology and Universal Design Defined

The term *mainstream technology* has no statutory definition or precise technical meaning. As the term is used here, it refers to any technology that is intended for general use rather than for use entirely or primarily by people with disabilities. The setting in which a technology is used may determine the classification of a technology. For example, a handrail in a place where one is normally found (e.g., beside steps in a school building) would be mainstream device, whereas a handrail installed along the hallway in the home of someone with mobility limitations would be an assistive device and an environmental modification.

Mainstream technologies include such disparate items as pens and pencils, personal computers, kitchen gadgets and appliances, cash machines, automobiles, cell phones, alarm clocks, trains, microwave ovens, and elevators. Some mainstream products, for example, Velcro, were not developed for people with disabilities but have come to have a variety of assistive uses. In some cases, the inclusion of accessibility features in general use products is required under Section 508 of the Rehabilitation Act or other legislation, as described below.

Universal design is the process of designing environments, services, and products to be usable, insofar as possible and practical, by people with a wide range of abilities without the need for special adaptation.[4] Other common terms for this process are "design for all," "inclusive design," and "accessible design."[5] Although "accessible design" might be considered a more inclusive term that encompasses mainstream products or environments with certain adaptations (e.g., wheelchair ramps), the term is often used interchangeably with universal design.

Among the most widely known examples of accessible mainstream products cited by proponents of universal or accessible design is a popular brand of kitchen tools and other gadgets that were designed from the start

[4]The term "universal design" was coined by the late Ron Mace, The Center for Universal Design, North Carolina State University College of Design.

[5]Some suggest reserving the term "accessible design" for design features or processes that meet legal requirements (Erlandson et al., 2007).

both to be attractive and generally useful and to be easily used by people with limited hand strength or dexterity (Mueller, 2000). In some cases, accessible design may mean the creation of a product or a building that is compatible with assistive technologies (e.g., wide doorways or ramps that accommodate wheelchairs) or that can be easily adjusted for different user characteristics. (See Box 6-1 in the preceding chapter for a list of selected universal design features for health care facilities.)

Another path to safer and more useful products is human factors engineering, which considers how people use products and how human capacities and expectations interact with the characteristics of products in different environments. As is also true of universal design, one focus of human factors engineering is the design of products and processes to reduce the opportunity for human error.

Human factors engineering often does not consider the capacities of people with visual, hearing, mobility, or other impairments. Nonetheless, its principles and methods can be applied to the design of mainstream and assistive technologies to take into account how people with different kinds of impairments interact with such technologies. Unfortunately, Wiklund (2007) concludes that although the application of human factors standards appears to have made some medical equipment more accessible, "a disturbing proportion of new devices still have significant shortcomings" (p. 273).

A recent edited work on accessible medical instrumentation proposed a number of design principles to improve accessibility and safety for a wide range of equipment users, including health care professionals as well as consumers and informal caregivers (Winters and Story, 2007a).[6] Desirable product features include easily located device controls with "on" and "stop" buttons that have common, distinctive designs and colors.

It must be kept in mind, however, that universal design is a *process* and not an outcome. In practice, a product or environment that can be used without adaptation by people with every possible kind of physical or mental impairment will rarely if ever be possible. Nevertheless, the process of universal design can significantly extend the range of users for many products and environments. It can also make the use of adaptive assistive

[6]In one definition, medical instrumentation is broadly defined to include "any furniture, measuring device, device that comes in contact with or is designed to be manipulated, monitored or read by health care professionals, lay person caregivers or end-user patients themselves as part of the provision or receipt of medical services, interventions or care, and any user-controlled software designed or required to be installed and used in connection with such technology, or any process or control system with which such patients or caregivers must interact in order for medical services, medical information, or treatment results to be achieved, measured or communicated" (Mendelsohn, 2007, p. 65).

technologies much simpler and less obtrusive. A web page designed so that it can easily be used with computer screen readers is an example.

Box 7-1 lists widely cited principles of universal design that may be applied to the planning of products, services, buildings, and environments such as parks and pedestrian spaces. (Story et al. [2003] have prepared a set of performance measures that can be used to assess how well products meet these principles.) Most of these principles are also useful reference points for those designing an assistive device, for example, to make its use simple and intuitive, to limit the physical effort required to use it, and to minimize the opportunity for error or unsafe use. Another principle that appears to guide much accessible design relates to style or attractiveness, that is, giving products pleasing designs that do not invite stigma.

In general, the broader the application of universal design principles to products, services, and environments is, the less the need for assistive or adaptive technologies will be. For public technologies, such as voting machines or buses, accessible design is the only method that works, because individuals cannot purchase or choose accessible versions of these kinds of devices on their own.

BOX 7-1
Principles of Universal Design

Equitable use. The design is useful and marketable to people with diverse abilities.

Flexibility in use. The design accommodates a wide range of individual preferences and abilities.

Simple and intuitive. Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

Perceptible information. The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

Tolerance for error. The design minimizes hazards and the adverse consequences of accidental or unintended actions.

Low physical effort. The design can be used efficiently and comfortably and with a minimum of fatigue.

Size and space for approach and use. Appropriate size and space are provided for approach, reach, manipulation, and use, regardless of the user's body size, posture, or mobility.

SOURCE: Center for Universal Design (1997 [copyrighted but available for use without permission; guidelines on file]).

KEY POLICIES THAT PROMOTE ASSISTIVE TECHNOLOGY AND UNIVERSAL DESIGN OF MAINSTREAM TECHNOLOGIES

Both before and since the publication of the 1991 and 1997 IOM reports, the U.S. Congress has taken steps to promote assistive and accessible technologies for people with disabilities. Some policies—notably, the Assistive Technology Act—aim to make different kinds of technologies more available, more useful, and more affordable. Other policies, such as coverage provisions of health insurance programs such as Medicare and Medicaid, do not focus on assistive technology as such but significantly affect access to it (see Chapter 9).

Section 508 of the Rehabilitation Act

In 1986, responding to the proliferation of copiers, computers, and other electronic and information technologies, the U.S. Congress added the Electronic Equipment Accessibility amendment to the Rehabilitation Act of 1973 (U.S. Department of Justice, 2000b). The amendment directed the General Services Administration and the National Institute on Disability and Rehabilitation Research (NIDRR) to develop guidelines for federal agency procurement of accessible electronic equipment. As described in Appendix F, the Congress responded to lax enforcement of the 1986 provisions with the Workforce Investment Act of 1998.

The 1998 legislation requires the electronic and information technologies acquired by federal agencies to be accessible to federal workers and members of the public with disabilities and to do so on the basis of standards developed by the Architectural and Transportation Barriers Compliance Board (known as the Access Board; see the description of the board in Chapter 6). The standards, which were issued in December 2001, establish technical criteria for making electronic technology accessible to people with sensory and mobility limitations. They cover telephones and other telecommunications, computers, software applications, video and multimedia products and applications, World Wide Web-based intranet and Internet information and applications, information kiosks, and office equipment such as copiers and fax machines.[7]

As described by the U.S. Department of Justice, the standards "cannot—and do not pretend to—ensure that all [electronic and information technology] will be universally accessible to all people with disabilities" (U.S. Department of Justice, 2000b, unpaged). Reasonable accommoda-

[7]The law does not require accessibility for equipment that has embedded information technology, such as heating and ventilation system controls, as long as the principal function of the equipment is not information management, storage, manipulation, or similar activities.

tions will still be necessary in some situations, but more attentiveness to accessibility will limit the need for accommodations.

Under Section 508, the U.S. Department of Justice is supposed to oversee federal agencies in conducting evaluations of their activities to assess the extent to which their electronic and information technologies are accessible to people with disabilities. The agency published its last such evaluation in 2000 (U.S. Department of Justice, 2000b). That report noted that Section 508 is "technology centered" and focuses on whether mainstream products meet regulations, whereas other provisions of the Rehabilitation Act (Sections 501 and 504) are "person centered" and focus on accommodations related to individual needs.

The National Council on Disability has recommended extending the provisions of Section 508 so that organizations receiving federal funds would be "prohibited from utilizing federal dollars to develop or procure technology that is inaccessible" (NCD, 2000b, unpaged). The council criticizes, in particular, the One-Stop employment centers (funded under the Workforce Investment Act) for not reliably providing or employing accessible information and telecommunications services. In addition, the council suggests that federal and state officials involved in acquiring electronic and information technology need more training in the evaluation of products for accessibility. This committee agrees that these enhancements to Section 508 would contribute to the expansion of accessible electronic and information technologies.

Assistive Technology Act of 1998

The Assistive Technology Act of 1998, which replaced a 1988 law and which was reauthorized in 2004 to continue through 2010, is the legislation most directly supportive of assistive technology. It authorizes federal support to states to promote access to assistive technology for individuals with disabilities. For fiscal year (FY) 2006, the U.S. Congress appropriated $26 million for the program. At this level of federal spending, most state programs are funded at levels below the $410,000 minimum grant award specified in the law (ATAP, 2006). Overall, the level of funding is quite low.

The 2004 reauthorization shifted the focus of the policy from infrastructure development to direct support for technology access by people with disabilities through financing assistance (loans), device exchange or reuse, and device loan programs. Funds can also be used for training, public awareness, and other programs. Programs cannot pay directly for devices for individuals.

Other Policies

In addition to the Rehabilitation Act and the Assistive Technology Act, a number of other policies affect the availability of assistive and accessible technologies. As described in more detail in Appendix F, these include policies on the compatibility of telecommunications equipment with hearing aids and the captioning of television programs. For example, the Telecommunications Act of 1996 requires that new video programming, including cable as well as broadcast television, provide closed captions that make programs accessible to people with hearing loss.

Although it does not fund the development of assistive technologies and implementation has been disappointing in many areas (see Appendixes D and E), the ADA potentially creates demand for certain assistive and accessible technologies as public and private organizations remove environmental barriers, as required by the law. For example, workplace accommodations may involve the purchase or rental of a variety of aids that allow the use of computers and other electronic equipment.

As mentioned earlier in this chapter, education policies and health care financing programs—notably, the Individuals with Disabilities Education Act, Medicare, and Medicaid—also affect access to assistive technology. In addition, the New Freedom Initiative, which was announced in a 2001 Executive Order proposed a number of steps to remove barriers to equal participation in society by people with disabilities (Executive Order 13217).[8]

EXTENT OF ASSISTIVE TECHNOLOGY USE

Assistive technologies have been developed to meet a wide range of needs. A database (ABLEDATA) developed by NIDRR includes information on more than 21,000 currently available assistive devices, up from about 6,000 devices listed in the early 1980s (OTA, 1985; ABLEDATA, 2006).[9] The database also includes some useful items that were not designed as assistive devices.[10] In addition, the database provides links to organizations

[8]How much has been accomplished under this initiative is difficult to gauge. A New Freedom Initiative website created by the U.S. Department of Health and Human Services does not provide much information specific to the initiative, and most of the specific information dates back to 2003 or earlier (http://www.hhs.gov/newfreedom/links.html).

[9]Beyond supporting research, as discussed in Chapter 10, NIDRR is also charged with providing practical information to professionals, consumers, and others; disseminating the knowledge generated by research; and promoting technology transfer.

[10]For example, some items, including a convection oven, are convenient for people with disabilities but appear to have been neither intended for their specific use nor deliberately designed to be accessible to as wide a range of users as possible. Items designed by applying universal design principles include a vegetable peeler aimed at the mass market but intentionally designed to be easy to use by people with limited hand strength or dexterity. Examples

that offer services or assistance, companies, publications, conferences, and consumer reviews of products. (The database service does not itself sell products.) According to a report by the U.S. Commerce Department, worldwide sales of American assistive technology products and services exceeded $2.85 billion in 1999 (Baker et al., 2003).

In a review of data from six national population surveys, Cornman and colleagues (2005) estimated that 14 to 18 percent of people age 65 and over used assistive technology. The authors noted that such surveys may underestimate assistive device use if they restrict questions about such use to people who have already reported that they have difficulty with daily activities and, thereby, exclude respondents who report device use but no difficulty. People may, for example, use a device but report no difficulty because the device is so successful and so familiar to them that they do not think of their underlying impairment when responding to survey questions.

Not surprisingly, when questions are limited to people with disabilities rather than the general population, surveys show much higher levels of assistive device use. A Kaiser Family Foundation survey found that 45 percent of nonelderly adults who reported having a physical disability said that they relied on equipment to help them with basic needs at home or work (Hanson et al., 2003).

A 2001 University of Michigan survey sponsored by NIDRR also focused on people with disabilities (Carlson and Ehrlich, 2005). On the basis of the survey responses, the researchers coded 75 different types of assistive devices. The four most commonly used technologies were canes or walking sticks, wheelchairs, hearing aids, and walkers. Other commonly used devices were scooters (often those provided at grocery and other stores rather than personally owned equipment), back braces, oxygen tanks, and crutches. Other surveys also find that mobility devices are the most common type of assistive equipment reported to be used (see, e.g., Russell et al. [1997] and Cornman et al. [2005]).

The University of Michigan survey found that 64 percent of the respondents used some form of assistive technology (Carlson and Berland, 2002; Carlson and Ehrlich, 2005). More than 85 percent reported the need for equipment or personal assistance, or both. Respondents under age 40 were more likely than older respondents to report that they have unmet needs for assistive technology. People with unmet needs were also more likely to be nonwhite, to have low levels of education and personal and family income, and to not be working. The majority of respondents reported that they had received little or no information about assistive technologies or

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of listed items that are intended primarily for use by people with specific impairments include a vegetable peeler with a clamp that allows use with only one hand and a carbon monoxide detector for use by people with hearing limitations.

about where to obtain them. They also thought that public awareness of the need for these technologies had increased in the preceding decade. The great majority (approximately 90 percent) agreed that changes in laws or program policies in the previous decade had helped people with disabilities get access to assistive technologies. As reported below, the survey asked respondents some questions about their use of other technologies and environmental access features.

Other surveys have also identified unmet needs for assistive technologies. For example, in a national survey of people with a spinal cord injury, multiple sclerosis, or cerebral palsy, Bingham and Beatty (2003) found that half of those surveyed reported that they needed assistive technology during the preceding year and that one-third of this group did not receive it every time that it was needed.

OUTCOMES OF ASSISTIVE TECHNOLOGY USE

> *Today, AT [assistive technology] provides alternate ways of providing transportation for those who cannot walk, communicating for those who cannot speak, reading for those who cannot see or read print, using the telephone for those who cannot hear and remembering for those who forget.*
>
> NTFTD (2004)

Assistive technologies may meet the needs of users in different ways. They may allow people to do something that they could not do before (e.g., use a computer or drive a car) or to do it more safely, more easily, or more independently. The ability to perform a discrete task, such as using an appliance, driving a car, or putting on socks, may translate directly or indirectly into better general functioning in daily life (e.g., getting dressed and preparing meals); more independence (e.g., traveling outside the home); or improved abilities to perform social roles, such as attending school, working, or taking care of one's children. These outcomes may, in turn, translate into a better quality of life. They may also reduce demands on family or paid caregivers.

In general, the usefulness of an assistive technology will depend on interactions involving several factors (see, e.g., Batavia and Hammer [1990], Thorkildsen [1994], and Scherer [2005]). These factors include

- characteristics of the individual user, such as a person's particular impairment, income, education level, and adherence to therapy regimens, as well as his or her preferences and goals;
- characteristics of the technology itself, including ease of use (with

respect to both physical and cognitive demands), ease of maintenance, need for training in use, reliability, safety, durability, portability, cost, and obtrusiveness; and

- environmental circumstances, including characteristics of an individual's home or workplace, family relationships, social attitudes, the knowledge and attentiveness of health care professionals, and supportive public policies.

In various ways that reflect their personal characteristics and environments, users (and those who advise them) balance the various pluses and minuses of specific devices or categories of devices. This balance helps determine what devices they will seek to use, what they will actually use (once a device is obtained), and when they will consider using a new device.

Despite the increasing use of assistive technologies and the creation of a number of federal programs to promote the development and availability of these technologies, the amount of information on the effectiveness of these technologies in improving function and, in particular, increasing independence and community participation appears to be relatively sparse across the range of available technologies and users (AAPM&R/The Foundation for PM&R, 2003; Carlson and Ehrlich, 2005).[11] As discussed in Chapter 10, government funding for disability-related research is, in general, very small in relation to the personal and societal impact of disability. More research to assess the effectiveness of existing and emerging technologies is important to guide consumer, clinician, and health plan decision making. The development of health outcomes measures as part of the National Institutes of Health's Patient-Reported Outcomes Measurement Information System (PROMIS) initiative (see Chapter 10) should improve the use of such measures in clinical studies, including studies that evaluate assistive technologies.

Some privately funded research is undertaken to support approval by the U.S. Food and Drug Administration (FDA) for certain complex devices. FDA makes the submission of clinical data demonstrating safety or efficacy in humans a condition of approval for only a small percentage of medical devices (FDA, 1999; IOM, 2005b).[12] Manufacturers must supply FDA with

[11]Consistent with the definitions used in much clinical and health services research, *effectiveness* refers to the extent to which an assistive (or mainstream) technology meets the needs of users in everyday life. (It may also refer to the extent to which the technology performs as intended.) *Efficacy*, in contrast, refers to outcomes in clinical trials or other controlled research settings.

[12]For example, in 2003, the FDA approved the iBOT, a battery-powered wheelchair that can rise to eye level, climb stairs and curbs, and traverse uneven surfaces by using a computer-controlled system of sensors, gyroscopes, and electric motors (FDA, 2003). The agency reviewed test data on the device's mechanical, electrical, and software systems and also

nonclinical safety and other technical data for a larger group of devices; and they must register a very much larger group of relatively simple devices, such as manual wheelchairs, canes, and braces. FDA also regulates the claims that manufacturers may make about devices. For example, in 1993, the agency warned hearing aid manufacturers to stop making misleading claims and to supply clinical data to justify certain claims (FDA, 1993).

Since publication of the 1991 IOM report, researchers have continued to work on outcome assessment tools that are suitable for testing the effects of technology use on different dimensions of functioning and disability.[13] NIDRR has funded research centers and projects to improve the measurement of outcomes from the use of assistive technologies and to promote the use of valid measures (NARIC, 2006a). It has also supported assessments of specific assistive technologies and funded several engineering research centers that focus on various types of technologies or technology needs (see Box 7-2 later in this chapter). Many of these activities involve other agencies, including the U.S. Department of Veterans Affairs and the National Center for Medical Rehabilitation Research. These agencies and a number of others also independently fund evaluations of technologies.

The committee identified a few controlled studies that compared assistive technologies or that compared the use of an assistive technology with no use. For example, several studies have compared hearing aids and other devices used to enhance hearing (see, e.g., Cohen et al. [2004], Mo et al. [2004], and Morera et al. [2005]). A number of studies have also focused on different features of wheelchairs or other aspects of wheelchair use (see, e.g., Cooper et al. [2002], Fitzgerald et al. [2003], Levy et al. [2004], Trefler

evaluated information from a prospective, nonrandomized study with 18 individuals (of 29 who were initially enrolled). These research participants were trained to use the device and were then observed for 2 weeks in the test device and 2 weeks in their regular wheelchair or scooter. As described in the agency's approval notice, 12 of the participants could climb up and down stairs alone with the device, whereas 6 required an assistant; but none could climb a single step with their regular device. (The only injuries that occurred involved minor bruising related to a fall out of the chair.) On a test of independence in functioning for a range of tasks (e.g., stair climbing), the participants showed more independent functioning when the task involved the device's special features but equal functioning when the device offered no advantage over the person's regular equipment. The device was, however, rated as difficult to maneuver compared with the maneuvering difficulty of the participant's regular device in the home. As a condition for approval, the device manufacturer agreed to provide data on device failures and adverse events for 2 years following its approval. In 2006, the Centers for Medicare and Medicaid Services concluded that several of the device's advanced features (e.g., its stair-climbing capacity) did not provide a clinically significant benefit (CMS, 2006d), as discussed later in this chapter.

[13]A recent review of instruments for measuring the outcomes of assistive technology use reported that most published reports about instruments or their use date to the mid-1990s or later (Smith et al., 2005).

et al. [2004], and Holliday et al. [2005]; see also Consortium for Spinal Cord Medicine [2005a]).[14]

Most controlled studies appear to involve technologies related to mobility or sensory impairments, although a number of studies have investigated the use of computer-based and other assistive technologies for children and adults with learning or cognitive disabilities. Controlled studies of equipment typically cannot use "blinding" strategies that limit researcher or participant awareness of which group is receiving a test product. For equipment essential to basic functioning (e.g., mobility equipment), the use of a no-treatment or placebo control group might be unethical.

Studies of outcomes may include functional assessments, but most research relies on self-reports of satisfaction or usefulness rather than direct assessments of functional outcomes. In the University of Michigan survey cited earlier, more than 90 percent of respondents reported being satisfied or very satisfied with their assistive technology (Carlson and Ehrlich, 2005). Approximately half reported that assistive technology reduced their need for personal assistance somewhat or a lot; less than 30 percent said that it had no effect. In addition, the majority of respondents reported that universally designed products, better-designed products, or environmental access features reduced their need for assistive technology and services a lot or some. Only about one-quarter reported no effect. Other mostly small, mostly European studies of several kinds of assistive technologies have also found that the majority of users report positive experiences (see, e.g., Sonn et al. [1996], Hammel et al. [2002], Roelands et al. [2002], Thyberg et al. [2004], and Veehof et al. [2006]).

Several population-based studies suggest that assistive technologies may substitute for or supplement personal care (Manton et al., 1993; Agree, 1999; Agree and Freedman, 2000; Allen, 2001; Hoenig et al., 2003; Agree et al., 2005). Some of this research suggests more specifically that the use of simple devices may substitute for informal care, whereas the use of complex devices may supplement the use of formal or paid care (Agree and Freedman, 2000; Allen, 2001; Agree et al., 2005). As might be expected, those whose difficulties are not resolved by the use of a technology are more likely than others to use personal assistance (Taylor and Hoenig, 2004). Using responses from the 1994–1995 National Health Interview Survey, Verbrugge and Sevak (2002) concluded that "controlling for factors that route people to different types of assistance, equipment is more efficacious

[14]For example, one pilot study in a nursing home setting examined functional outcomes and quality of life before and after the provision of individually prescribed seating and mobility systems for 60 users of wheelchairs (Trefler et al., 2004). The investigators concluded that after the new system was provided, the participants "had less difficulty independently propelling their systems and increased forward reach, quality of life for social function and physical role, and satisfaction with the new wheelchair technology" (p. 18).

than personal assistance" (p. S366). They also noted that their conclusions needed to be tested with longitudinal studies.

At least one controlled trial (Mann et al., 1999) found cost savings with the substitution of assistive technology for some personal care.[15] Using a variety of outcome measurement tools, the investigators also found that the group that used the technology experienced slower rates of functional decline and less pain than the control group.[16]

As is evident from this discussion, the availability of assistive and accessible mainstream technologies may have consequences that reach beyond individual users to affect formal and informal caregivers, including family members. Family member caregivers may, for example, find that a new assistive technology reduces physical and emotional stress. In some cases, it may reduce the caregiving requirements sufficiently that family members can work outside the home or be more productive in their paid work. Assistive technologies that allow children to perform better at school and adults to work or to work more productively will also likely benefit others, including teachers, employers, and coworkers. Overall, then, the effective use of assistive technologies may benefit society as a whole to the extent that such use reduces dependency and increases productivity (per worker and per member of society). The committee found little empirical research on these kinds of outcomes (however, see, e.g., Pettersson et al. [2005]). Evaluations of outcomes involving family members and others would permit a fuller understanding of the effects of an assistive or accessible technology.

ENHANCING ACCESSIBILITY THROUGH UNIVERSAL DESIGN OF MAINSTREAM TECHNOLOGIES: PROMISES AND PROBLEMS

When technology and disability are discussed, assistive technologies are usually the first things that come to mind. As emphasized earlier in this chapter, however, people with disabilities encounter and must use—or be disadvantaged by an inability to use—a very wide range of mainstream technologies in their daily lives. Standard alarm clocks, microwaves, ovens, washing machines, thermostats, computers, and a host of other products

[15] Another controlled study with older adults with chronic conditions evaluated a package of interventions (e.g., exercise, instruction in problem-solving strategies, home modifications, and related training), most of which did not involve equipment (Gitlin et al., 2006). The investigators reported that participants in the intervention group had fewer difficulties with activities of daily living and instrumental activities of daily living, a greater sense of self-efficacy, and greater use of adaptive strategies.

[16] Assessment instruments included the Functional Independence Measure (motor and cognitive sections), the Older Americans Research and Services Center Instrument, and the Craig Handicap Assessment and Reporting Technique (physical independence, mobility, occupation, and social integration sections).

may not be accessible (either directly or with adaptive technologies). In that case, then, people must do without, accept products with significant shortcomings, or buy special products, often at a higher cost. The nation's aging population should spur the growth of a market to support—and demand—the development and availability of more accessible mainstream products, although the larger part of this market will be people with milder impairments. Table 7-1 summarizes some key mainstream technologies and the barriers that they can present to people who have various kinds of physical or cognitive impairments.

With electronic technology being integrated into products and services in education, employment, health care, and many other aspects of daily life, the inability to use these electronic features can itself be disabling. For example, a person with vision loss who could work a traditional stove

TABLE 7-1 Examples of Barriers Created by Mainstream Technologies

Mainstream Use	Example of Barrier
Medical diagnosis	Magnetic resonance imaging devices that do not allow use by people with spinal deformities or morbid obesity Mammography machines do not accommodate women in wheelchairs or scooters
Medical therapy or monitoring	Home blood pressure monitoring devices that are difficult for people with low vision to read Alarm systems on glucose monitoring devices that have no visual indicator for people with hearing loss
General built environment	Buildings with doors, hallways, seating areas, and other features that are awkward or impossible for people with mobility limitations to use
Activities of daily living	Ovens, washing machines, and other appliances in rental apartments that have touch screens or other features that limit their use by people with vision or other impairments New products that require complex sequences of commands that exceed the capacities of people with cognitive impairments or that require intensive training
Information technology	Displays on fax and other machines that are positioned so that they are not visible to people in wheelchairs Commercial firms that operate only through the Internet and that have websites that are not compatible with computer screen readers used by people with vision impairments
Transportation	Buses that have access features that are not functioning because of a lack of timely maintenance and repair Fare machines that are difficult to use by people with cognitive limitations or that assume a person's familiarity with operating procedures

with knobs that click through the heat settings may not be able to use a replacement that relies entirely on touchpad controls with no audible or tactile cues.

In addition, electronic devices are increasingly replacing human agents for transacting business—whether the business is getting cash, checking out groceries, or purchasing tickets. Often, these devices and their specific features are designed without attention to people with vision, hearing, manual dexterity, or other impairments.

Progress, albeit slow, is being made in some areas to counter some of these barrier-creating developments. For example, in 2004, the Access Board published final guidelines advising that automated teller machine (ATM) instructions and other user information be accessible to people with vision impairments (Access Board, 2004). In the preamble to the guidelines, the Access Board noted that it was not extending the guidelines to other types of interactive transaction machines and that it would monitor application of the existing standards under Section 508 of the Rehabilitation Act for federal agencies purchasing such machines. (These guidelines have not yet been formally adopted as regulations by the U.S. Department of Justice, although a notice of proposed rule making was published in 2005 [Department of Justice, 2005a].)

Although ATMs were mentioned explicitly in the ADA, the Internet was a thing of the future in 1990, when the ADA legislation was passed. Now, the Internet is becoming the primary or least expensive place to obtain certain types of goods, particularly specialty items that may not be available in many smaller communities. If computer technologies in general and websites in particular are not accessible, people with disabilities may face serious limits in their ability to find and purchase these less common products, including certain assistive technologies.

The accessibility of computers generally and the Internet specifically is a particular concern of many policy makers, consumer advocates, researchers, and software and hardware producers (see, e.g., Novak [2001], Kirkpatrick et al. [2006], and W3C [2006]; see also Appendix F to this report). A report from the U.S. Department of Commerce, which used data from the September 2001 supplement to the Current Population Survey, reported that "with the exception of those individuals with severe hearing impairment, those who have [one of several categories of] disabilities are less likely than those without a disability to live in a home with a personal computer. And even in homes with a computer, people who have at least one of these disabilities are less likely to use the computer or the Internet" (NTIA/ESA, 2002, unpaged). Some access problems may relate to the economic disadvantages of people with disabilities and their lack of financial resources to buy a computer or Internet access. Inadequate design remains a factor, particularly for

people with visual impairments who may find, for example, that web pages are not compatible with computer screen readers.

Sometimes designing mainstream devices so that they are compatible with an assistive technology—as is done by designing computer screen readers—is the only practical strategy for achieving access. Often, however, the most economical and effective approach is to have the mainstream device designed so that no additional adaptive equipment is needed, as happens when buildings are designed without steps or when elevators "announce" their arrival and their stop status.

Although the desirability of having mainstream products accessible to a wide range of individuals is clear, product research and development incentives in this area follow the same principles identified below for assistive technologies. Unless there is the prospect of a market and significant additional revenues, companies have little motivation—other than the need to comply with regulations—to include any particular accessibility features in a product. Regulatory approaches do not, however, work well if enforcement is lax or if the perceived real or opportunity costs of complying are higher than the costs (e.g., fines) of not complying.

Even accessibility features that are known or expected to increase revenues must compete with other features for engineering and marketing time. If another feature appears to have a significantly greater profit potential, then the accessibility feature is likely to get a lower priority (Tobias and Vanderheiden, 1998; Vanderheiden and Tobias, 2000). As a result, access features may sit fairly near the top of a list of proposed features for a product and yet never make it into new releases of the product.

As discussed earlier, the U.S. Congress has adopted policies to require accessibility for certain services or products, primarily in the area of telecommunications. One significant challenge to policy makers and regulators is keeping up with technological advances. An example is the development of wireless and Internet-based telephone services (see Appendix F).

CHALLENGES TO DEVELOPMENT AND EFFECTIVE PROVISION AND USE OF ASSISTIVE TECHNOLOGIES

As illustrated in the discussion to this point, assistive technologies constitute a quite broad and varied array of products that are directed toward a very diverse population of device users. Encouraging private firms and individuals to imagine, develop, and produce useful technologies presents many challenges and obstacles. Even when a good product is available, a number of barriers—such as a lack of consumer awareness of technologies and a lack of financial access—may lie in the path that leads to its successful, continued use by people with disabilities.

Viewed broadly, the process of creating, providing, and supporting

technologies for use by people with disabilities has several stages. They stretch from the earliest glimmerings of a product or process idea through the end of a product's useful life or its replacement by an improved product. These stages, which also characterize many—if not most—mainstream consumer products, include

- product research and development;
- commercial application and production;
- consumer and professional awareness;
- guidance and product selection;
- financial access to equipment and related services;
- personal adaptation, training, and use; and
- product maintenance, repair, and replacement.

The characteristics of these stages vary considerably for different kinds of products and companies. Some products, such as advanced prosthetic limbs, may be characterized by complexity at every stage, requiring substantial investment in applied research and commercial development as well as major financial, technical, and other support for users. After their initial conceptualization and development, other products, such as the shower chair or the button hook, may see little continued innovation, minimal user training (even when advice about the product's safe use might be advisable), and a limited risk of obsolescence, even though competitive products may emerge (e.g., Velcro and other fastening options for clothing). Lack of consumer awareness may be the biggest challenge for such established products.

Nonetheless, even for relatively simple devices, human factors engineers and others may see ways to improve the safety and functionality of the devices, for example, by changing the dimensions or the shape so that a device is more easily gripped or manipulated. As the next section describes, that a device can be improved does not necessarily mean that a manufacturer will be motivated to invest in bringing the improved device to market, particularly if the likelihood of a reasonable return on its investment appears to be low.

Many of the challenges or problems reviewed below relate to weaknesses in the market for assistive technologies, including prescribed medical devices of various sorts. On the demand side of the market, sales may be limited by the small numbers of prospective purchasers for many products, the lower-than-average incomes of many people with disabilities (see Chapter 3), and health plan coverage of assistive technologies that is more restrictive than coverage of medical and surgical services (see Chapter 9). In addition, consumers, their families, and the health care professionals who advise them may not even be aware of relevant product options or may find them difficult to evaluate. On the supply side, innovators and

entrepreneurs may, depending on the product, face high capitalization costs for manufacturing facilities and distribution networks, as well as significant research and development costs, particularly if the product requires the submission of data on safety and efficacy to the FDA. In comparison to the pharmaceutical industry, the medical device industry is characterized by a greater presence of small firms, a lesser reliance on patents as a source of competitive advantage, and a more continuous process of product refinement and innovation (Gelijns et al., 2005).

The following discussion first examines the stages of research, development, and commercial application for assistive technologies. It then considers the use of technologies by consumers.

Product Research and Development

> *It's mind boggling when you think of the things [assistive technologies] they're coming up with. What higher-level quads like me couldn't do before, we can do now. What a big incentive to keep going. There are so many advantages . . . I mean I'm glad I broke my neck in this century.*
>
> Brian, as quoted by Scherer (2005)

This enthusiastic, if somewhat startling, view of what technology can do to increase functioning and independence for people with disabilities was offered not in 2005 but in 1986. By that time, innovations in materials and in electronic and computer technologies had brought significant improvements in technologies for people with spinal cord injuries and other mobility-limiting conditions. The next two decades have seen many further technological advances and benefits, including lighter and more effectively controlled wheelchairs and prosthetic limbs and better knowledge of how to fit and maintain such devices to minimize the development of pressure ulcers and other secondary health conditions.

A number of analyses have, however, identified an array of obstacles to technological development and innovation in assistive technologies (see, e.g., IOM [1997], NCD [2000b, 2004a, 2006] and Baker et al. [2003]). Most relate to the relatively small market for many products, but product affordability is also an issue. Obstacles may also include a continuing legacy of discrimination and inattention to people with disabilities in medical research and engineering (Seelman, 2007).

Role of the Private Sector in Research and Development

In the private sector, the development and production of assistive technologies involve a diverse population of organizations (Baker et al., 2003). These organizations range from relatively large companies that produce

wheelchairs or hearing devices to niche firms that produce products for small and dispersed populations (e.g., adults and children who are both blind and deaf).[17] In addition, the assistive technology industry includes individual professionals who custom produce items such as adapted vans, braces, and orthotics. In general, small firms play a much bigger role in the medical device and assistive technology sector than they do in the pharmaceutical sector.

For products for which the potential for profit is good, private companies will typically take the lead in product research and development and continuing improvement. For many assistive products, however, the potential for sales and profits will appear low. For example, among people who could potentially benefit from electronic augmented communications devices, the range of abilities and communications needs is quite varied. Thus actual core technologies may likewise be quite varied. For example, several device control options are available (keyboard, infrared head pointer, hand gestures) (see, e.g., Bauer [2003]). As a result, the market for the general product category is quite fragmented, which tends to increase costs and limit profit potential.

Restrictive insurance coverage exacerbates the disincentive for product development for these and other product categories (see Chapter 9). For example, in a controversial and disappointing decision, the Centers for Medicare and Medicaid Services has determined that the iBOT (described earlier in footnote 12) meets the definition of durable medical equipment and qualifies as reasonable and necessary for people with certain mobility limitations; but it further determined that several integrated functions of the device, such as those that allow it to climb stairs, do not offer clinically significant benefits (CMS, 2006d). The agency also declined to create a new coverage category for the device, which critics argue effectively denies coverage since Medicare covers only the least costly device in a category, which in this case is the category for a standard power wheelchair (see the critique from the ITEM Coalition [2006]). (The iBOT sells for more than $25,000, and the company sold approximately 1,000 of the devices in its first 3 years on the market [Young, 2006].)

A 2003 report by the U.S. Department of Commerce cited a number of difficulties facing the assistive technology industry. They include "the prevalence of small firms [who lack resources for sophisticated product de-

[17]People with low-incidence disabilities and children with certain disabilities are two examples of populations that may require public-sector support for product development. Even when the number of children with a condition is sizeable, children's growth and development mean that many different sizes of a product may be required. Unlike a medication, which often can be provided in different doses to people of different ages, many medical devices and assistive technologies cannot be manufactured in one form and then easily "sized" at the time of delivery or use (IOM, 2005b).

velopment] . . . ; problems in hiring and retaining a trained workforce; . . . and the disconnect between . . . industry and the resources of the federal laboratory system" (Baker et al., 2003, unpaged). The report cited survey data indicating that research and development was a significant activity for less than half of the firms surveyed, and only 15 percent of the firms surveyed cited activity in basic research.

The 1997 IOM report *Enabling America* suggested that the situation for assistive technologies is similar to that for so-called orphan drugs for people with rare medical conditions.[18] Unfortunately, it has proved difficult for the U.S. Congress to identify incentives for the development of medical equipment for small user populations similar to those identified for the development of orphan drugs (IOM, 2005b). In language accompanying the 2002 appropriation for the U.S. Department of Education and other agencies, the Senate Committee on Appropriations stated that "priority for grants [under the Assistive Technology Development Fund] should be given to the development of technology that has a limited number of users, or orphan technology" (U.S. Senate, Committee on Appropriations, 2001).

Role of Government in Research and Development

If private industry finds investment in product development activity in a particular area unattractive, the primary alternative is government-supported research and development or, occasionally, research supported by private foundations. As described in Chapter 10, government investment in disability and rehabilitation research of all kinds—including most kinds of product innovation and development—is limited relative to the population that could benefit. One exception is investment in prosthetic research, which has received substantial support from the U.S. Department of Veterans Affairs and the U.S. Department of Defense and which has become a particular focus with the return of military personnel who have lost limbs in Iraq or Afghanistan (Perlin, 2006; see also Chapter 10).

NIDRR funds a number of Rehabilitation Engineering Research Centers that conduct research and development related to specific populations,

[18]For drugs, Congress has defined a rare disease or condition to mean one that either affects less than 200,000 people in the United States or affects more people but for which there is "no reasonable expectation that the cost of developing and making available in the United States a drug for such disease or condition will be recovered from sales in the United States" (PL 97-414, Section 526 [360bb](a)(1)). For medical devices that require FDA approval, Congress created special exemptions from certain regulations for humanitarian use devices, which are "intended to benefit patients in the treatment or diagnosis of a disease or condition that affects or is manifested in fewer than 4,000 individuals in the United States per year" (21 CFR 814.3(n)). For a description of these provisions, see the report of FDA (2006.) These provisions affect very few devices.

technologies, or strategic issues (Box 7-2).[19] The centers may work on accessible mainstream technologies (e.g., household products and computers) as well as assistive technologies. Some centers focus on conditions (e.g., spinal cord injuries), some focus on technologies (e.g., wheelchairs), and some focus on environments (e.g., workplaces). Intensive consideration of assistive technologies in different environments may bring new and useful perspectives on environmental barriers to work and social life and on engineering strategies for removing or mitigating these barriers.

Total funding for the centers program was relatively steady at about $11 million in the late 1990s, but in FY 2000, the funding increased to more than $15 million and increased again in FY 2001 to more than $20 million as additional centers were funded (Arthur Sherwood, Science and Technology Advisor, NIDRR, personal communication, November 16, 2006). It has declined slightly since then. The funding for each center is modest, however, averaging less than $1 million per center per year.

Government support for research is not restricted to government and academic researchers. The U.S. Congress has specified that a portion of certain government agency budgets for assistive technology, science, or engineering research be allocated to support technological innovation in the small business community and to encourage commercial applications of technologies developed through government-supported research (SBA, 2001).

Involvement of Consumers at the Research and Development Stage

Although discussions of research and development focus on the roles of public- and private-sector organizations and funding, the development of a successful product—one that works and that is commercially feasible—often depends on consumer involvement, for example, through focus groups and evaluation of prototypes (see, e.g., Lane [1998] and Scherer [2005]). The 1997 IOM report *Enabling America* called for consumers with potentially disabling conditions to be involved in research and technology development and dissemination.

For certain products, the ability of companies to assess market demand and profit potential may be restricted by the limited market data on people with disabilities, including their numbers, their perceived needs and preferences for assistive and accessible products or services, and other characteristics. A recent national task force report recommended—and this committee endorses—government support for surveys and market research to help reduce the knowledge gap (NTFTD, 2004).

In some cases, companies could also benefit from information on the

[19]The Rehabilitation Act of 1973, which established NIDRR, provided for agency support for these centers, and the program began with five centers.

BOX 7-2
Focus of NIDRR-Supported Rehabilitation Engineering Research Centers

Condition, impairment, or group characteristic
- Spinal cord injuries
- Low vision, blindness, and multisensory loss
- Children with orthopedic disabilities
- Technology access for land mine survivors
- Technology for successful aging

Technology
- Accessible medical instrumentation
- Wheeled mobility
- Prosthetics and orthotics
- Communication enhancement
- Telecommunications access
- Wireless technologies
- Universal interface and information technology access
- Universal design and the built environment
- Telerehabilitation
- Robotics and telemanipulation (machines that assist with recovery from stroke)
- Recreational technologies and exercise physiology

Other
- Workplace accommodations
- Accessible public transportation
- Wheelchair transportation safety
- Technology transfer

SOURCE: NARIC (2006b).

broader market, for example, how people without mobility or sensory limitations view various accessibility features for mainstream products. Even with a rapidly growing older population, companies may be concerned that people may avoid products that suggest disability, and firms may be unaware of universal design principles that include the attractiveness of a product to a broad range of users (Vanderheiden and Tobias, 2000).

A rather different way of involving consumers has to do with the development of technical standards that are appropriate for different populations. As noted in Chapter 6, the U.S. Department of Veterans Affairs—citing the average age of its population—has developed standards for its facilities that differ somewhat from the standards developed by the Access Board. Many of the data on human performance standards and guidelines were derived from studies that relied heavily on young male participants

(Gardner-Bonneau, 2007). If the average user of, for example, home medical equipment is an older woman with mobility or sensory limitations, or both, then the development of equipment using standards derived from data based on a population that is quite different is not appropriate. Data on older populations and children are available but are not necessarily widely known. Designers and standard setters are, however, beginning to take note, as evidenced by the publication by the Access Board of ADA building accessibility guidelines relevant for children (Access Board, 1998; see also ISO [2001], Fisk et al. [2004], and Kroemer [2006]). (The U.S. Department of Justice has not yet adopted these guidelines as standards.)

Challenge of Technology Transfer and Commercial Application

A good product idea, design, or prototype is of little value to consumers if it does not lead to commercial production and distribution. Even when the federal government supports research and development in the area of assistive and accessible products, this support may not extend far enough into the next stage, that is, technology transfer for the purposes of commercial application (Wessner, 2006). One definition of technology transfer is the "process of converting scientific findings from [government or academic] research laboratories into useful products by the commercial sector" (NLM, 2006, unpaged). One of the recommendations (Recommendation 8.1) in the 1997 IOM report *Enabling America* implicitly defined technology transfer more broadly to include what this report characterizes as steps to increase consumer and professional awareness of the available technologies.

The gap between long-term, government-supported basic research and short-term product development by industry has been characterized as the "valley of death" (see, e.g., Fong [2001]). For example, in 1998, a congressional committee used that term to label a "widening gap between federally funded basic research and industry-funded applied research and development" (U.S. House of Representatives, Committee on Science, 1998, unpaged).

The U.S. Congress and federal agencies have taken some steps to promote and monitor technology transfer from government research agencies to the private sector through research and development partnerships; the implementation of patenting, information disclosure, and licensing procedures; the provision of technical assistance; standards development; and other means (see, e.g., U.S. Department of Commerce [2006]). Unfortunately, the effectiveness of these steps in the area of assistive technology has been limited by the industry and market characteristics described above (Bauer, 2003). To encourage technology transfer, each of the previously mentioned Rehabilitation Engineering Research Centers is expected to pro-

duce some transfer of technology to the private sector. NIDRR has also funded a center (at the State University of New York at Buffalo) specifically to promote transfer for assistive technologies.

Even with government support for product development and applied research, product developers, governmental agencies, and advocates may have to invest considerable effort to identify and attract a private company that is prepared to manufacture and market a product. In the U.S. Department of Commerce survey cited earlier, almost two-thirds of the companies surveyed indicated that they were "passive in their pursuit of new ideas—or not interested at all" (Baker et al., 2003, unpaged). More positively, almost 60 percent said that they would be interested in working with government research and development agencies, although their lack of knowledge of these agencies and their procedures may impede collaboration.

Awareness, Adoption, and Maintenance of Available Technologies

Consumer Awareness

When suitable assistive or accessible products are commercially available, other barriers may still stand in the way of their effective use. At the most basic level, people with disabilities (and their family members) may not be aware of the availability of useful products. In addition, particularly in the case of older people who have gradually developed functional limitations, people may not recognize that they could benefit from assistance (Gitlin, 1995; NTFTD, 2004; Carlson et al., 2005). Also, people who acquire disabilities later in life and who have trouble accepting their situation may see some assistive technologies as stigmatizing, which points to an advantage of accessible mainstream products (NTFTD, 2004). As Caust and Davis (2006, unpaged) have observed, "[p]eople want to believe they are competent and capable and they are happy to ignore the safety risks associated with not using assistive technology, for the sake of appearing competent."

The University of Michigan survey of people with disabilities discussed earlier in this chapter reported that roughly half of the respondents reported that they had received little or no information about assistive technologies. This finding suggests that the needs for information about assistive technologies are going unmet. Among the respondents who did obtain information, about half mentioned health care professionals (e.g., occupational or physical therapists) as the source (Ehrlich et al., 2003). (Many of the technologies reported by respondents, e.g., wheelchairs and hearing aids, require a medical prescription or guidance.) About 15 percent mentioned family and friends as sources of information, and 13 percent mentioned vocational rehabilitation counselors.

At the time of the survey in 2001, less than 10 percent of the respondents mentioned the Internet as a source of information. With the explosion of Internet resources and increased computer use by older individuals and their family networks, the Internet would likely be cited more frequently today. Internet searches may lead people to resources such as ABLEDATA, Technology for Long-Term Care (www.techforltc.org, which was originally funded by the U.S. Department of Health and Human Services), and other information resources developed by governmental agencies, nonprofit organizations, and manufacturers.

Although NIDRR, which administers the Assistive Technology Act of 1998, supports activities to help increase consumer awareness of useful technologies, the agency's website is (in the committee's view) not easy to use as a resource to find information about assistive or accessible technologies. Government and support group websites are especially important resources for developing consumer awareness because company advertising and other promotional activities may be very limited for small markets.[20]

More can be done to ensure that people with disabilities and their families become aware of and educated about the range of technologies that are available to them to meet many of their specific needs. A national task force recently proposed a broad-ranging public awareness campaign "to communicate the existence and benefits of [assistive and accessible technologies], provide mechanisms for consumers to find accessibility features in [other] products, and showcase best practices" in universal design (NTFTD, 2004, p. 43). The committee offers a similar recommendation below.

In addition, further investigation of the extent and quality of Internet and other information resources (including support group and industry websites) would be helpful in developing strategies to improve the availability, reliability, and usefulness of the information available online. To the extent that the Internet is the focus of public education and information programs, it is important that policy makers and advocates be alert to gaps in Internet access and use among low-income and other consumers and that they investigate additional strategies that can be used to reach these groups.

[20]The direct-to-consumer television advertisements for scooters and power wheelchairs (which prominently mention Medicare coverage) are the exception rather than the rule, but they also contribute to government concerns about fraudulent and abusive marketing. These concerns have provoked various government efforts to curtail abuse; these efforts, in turn, have been criticized by consumer and suppliers as draconian (see, e.g., Jalonick [2006] and RESNA [2006]; see also Chapter 9).

Guidance for Health Professionals

The move from awareness to the acquisition and application of a technology may be as simple as going to a store, buying a new household gadget, and using it, possibly without the need for even simple instructions (e.g., as with an accessibly designed utensil that replaces a similar but less user-friendly device). In the case of advanced prosthetic devices and other technologies, the process may be complex, involving the expertise and guidance of highly trained medical and other specialists in the selection and individual fitting of equipment, the training of the consumer in its safe and effective use and ongoing maintenance, and periodic reevaluation of equipment performance and use.

Physicians who specialize in care for people with particular disabilities may be aware of products that require medical assessment and prescription, but they may not always be well informed about household and other products that could benefit their patients. For both simpler and more complex technologies, physicians and other health care professionals should be alert to their patients' ability to benefit from assistive technologies and be prepared to provide guidance and information or to refer them as appropriate to other information sources.

However, even with products requiring medical assessment and prescription, the rapid changes in some kinds of technologies and the introduction or disappearance of products or product models from the market may make it difficult for physicians to track and evaluate specific products. Thus, for example, instead of recommending a particular device, a clinician may determine that a consumer has impaired manual dexterity; evaluate what product features may be relevant, given the individual's fine motor skills; identify the need for products with features such as large control buttons; and then focus on products with the relevant features. For products that do not require a medical prescription, such as household products, the consumer or a family member may then take the lead in searching for products with the appropriate features.

For some types of assistive technologies, personnel who are trained and knowledgeable about product options and selection may be in short supply, as may be the physical locations where products can be viewed and tried. For example, the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) has stated that there are not enough occupational and physical therapists certified as assistive technology practitioners or certified suppliers with the expertise needed to serve people who need powered mobility devices (RESNA, 2005). Likewise the American Foundation for the Blind has stated that a "critical shortage of professionals who are qualified to provide specialized computer skills training to blind and visually impaired people significantly affects their viability in today's

job market" (AFB, 2001, unpaged). In yet another arena, the National Council on Disability has observed that it means little to recommend that the role of assistive technologies be considered more fully in the development of individual education plans (under the Individuals with Disabilities Education Act) if no member of the team developing such plans "is familiar with the range of [technologies] available to address desired goals (NCD, 2000b, unpaged).

Some consumers find information through state programs that have been funded under the Assistive Technology Act to aid consumers in learning about and acquiring technologies. For example, in a report on state activities funded under the Assistive Technology Act, RESNA (2003) found that the 34 states that provided data reported that they supported or operated 109 assistive technology demonstration centers. States also reported providing information to consumers through the Internet, e-mail, regular telephone and text telephone, and regular mail.

Financial Access

Particularly for the more expensive assistive technologies, a lack of financial resources can be a significant barrier to the acquisition of an effective, recommended technology. According to the University of Michigan survey of people with disabilities, the percentage of respondents for whom assistive technologies were paid for through public or private insurance (38 percent) was about equal to those for whom their equipment was paid for personally or through family members (37 percent) (Carlson and Ehrlich, 2005). Six percent received their equipment at no cost to themselves. People with low incomes were far more likely than people with higher incomes to report unmet needs for technology.

About 23 percent of the survey respondents sought help from an agency in selecting or purchasing equipment, and about 19 percent reported receiving help from an agency (Carlson and Ehrlich, 2005). Most people believed that they did not need agency help, but some said that they did not know an agency to contact. This again suggests the need for a more intensive public awareness effort.

As discussed further in Chapter 9, Medicare and private insurance coverage of assistive technologies is limited and often complex. Medicaid programs, for those who qualify, tend to cover a wider range of assistive technologies. This coverage is sometimes provided under waiver programs that do not extend to all parts of a state or to all categories of Medicaid recipients. The rules are often complex for consumers, family members, and even professionals.

One option for improving access to assistive technologies is through innovative practices in leasing or rental arrangements. One example is a leas-

ing arrangement developed by the Center for Assistive Technology at the University of Pittsburgh Medical Center (UPMC) in conjunction with the UPMC Health Plan, a manufacturer of costly power wheelchairs, and a local network of suppliers (Schmeler et al., 2003). The program is specifically designed to make the equipment quickly available to people with rapidly advancing health conditions (e.g., amyotrophic lateral sclerosis) whose use of the equipment may be limited to a period of months. Rather than the Health Plan purchasing a $25,000 power wheelchair for a consumer, the chair can be leased on a monthly basis for a reasonable fee. The fee includes the provision of all maintenance and upgrades as the person's condition changes. Once that person no longer uses the equipment, it is recycled and re-leased. With the program, people with these conditions have access to equipment much sooner and the health plan claims significant cost savings. The suppliers and the manufacturer do not consider the program to have interfered with their profit objectives because the equipment can be leased repeatedly over several years.

A particularly weak point in the chain of effective technology use is coverage for maintaining, repairing, and replacing an assistive technology when necessary. Some users may have the knowledge and physical abilities to repair simple products, but expert assistance will often be required, especially for complex and expensive equipment. In addition, when an effective product is prescribed and is then used and wears out, people often find that their insurance does not provide for replacement or does not provide for replacement frequently enough. Chapter 9 recommends revisions in health plan policies to increase access to assistive technologies and support their maintenance, replacement, and repair.

Although the committee did not locate specific documentation, committee members working in rehabilitation reported decreasing numbers of assistive technology clinics and programs within hospitals and reductions in the scope of programs related to reduced rates of reimbursement and other onerous provider payment policies. (See footnote 2 in Chapter 9 on the controversy about restrictions on reimbursements to inpatient rehabilitation facilities.) An analysis of the complex issues of payment for rehabilitation services was beyond the committee's resources. Still, without mechanisms in place to fit equipment and adapt or train individuals in its proper use, even a potentially very effective assistive technology can fail.

Through the Consumer's Eyes

One challenge for health care professionals, family members, and others who may be involved in discussions of assistive technologies is to consider outcomes "through the consumer's eyes" (see, e.g., Taugher [2004] and Lilja et al. [2003]). Each of these parties may have priorities different

from those of the individual considering or using an assistive technology (Scherer, 2005).[21]

For example, from a user's perspective, a seemingly inferior device may be more practical to use and maintain, may be less obtrusive in social situations, or may otherwise be more acceptable, and thus more effective than a more sophisticated device. Seigle cites the case of a man who had lost both arms in an accident.

> *Robotic arms were created and fitted to the man, but because they were heavy and uncomfortable they stayed on the floor of his closet. When the man asked what he most wanted to do on his own, he answered that he just wanted to be able to go out to a restaurant and drink a beverage without someone having to hold the cup. . . . In this case, the best assistive technology solution was a long straw.*
>
> Seigle (2001, unpaged)

In reality, although this anecdote highlights the mismatch between a technology and the user, a better solution for this individual would be prostheses that were lighter, more comfortable, and more functional. As described earlier, prostheses are the focus of considerable advanced research that has been given added impetus because of the wars in Iraq and Afghanistan, although cost will limit access to the more advanced devices for many individuals with limited or no insurance.

Research and experience suggest that consumer involvement in the selection process (rather than an essentially one-sided prescription by a health care professional) helps avoid later rejection or abandonment of the technology (see, e.g., Phillips and Zhao [1993], Gitlin [1995], and Riemer-Reiss and Wacker [2000]). Abandonment or nonuse of a technology, particularly an expensive one, is a costly and wasteful outcome that contributes to policy maker and insurer concerns about the provision of coverage for assistive technologies and to the adoption of restrictive coverage policies and practices. The committee found no evidence, however, that the rate of abandonment of assistive technologies is higher or even equal to the rate at which people fail to complete or maintain complex medication regimens.

RECOMMENDATIONS

Creating more accessible environments—whether through the provision of better assistive technologies and improved mainstream products or the removal of barriers in buildings and public spaces—is an important avenue

[21]Committee members reported hearing the label "inflictor" applied to professionals who prescribe or select assistive technologies without involving the consumer and considering that person's views about what will work in his or her own life.

to independence and community participation for people with disabilities. This chapter has identified needs in two broad areas: the development of new or improved technologies and the better use of existing technologies. The discussion below sets forth three recommendations related to these needs. Chapters 6 and 9 identify additional steps related to regulatory and financing policies.

Innovation and Technology Transfer

New and more effective assistive technologies are possible. For products with large markets, a good business case for investment in research, development, and production can often be made, although it may still be useful for consumers, policy makers, and others to become more articulate and persuasive in encouraging investment. Unfortunately, many types of assistive technology do not fit this model, and normal market processes fall short in meeting urgent consumer needs.

Tackling this shortfall is, however, complex. Although government efforts to promote assistive technology development and commercial applications do appear to have had positive results, the committee concluded that a more detailed exploration of obstacles, possible incentives, and even mandates would be useful. This exploration could build on the analyses cited in this chapter and other related work. It should involve a broad range of participants and should use subgroups as appropriate to investigate issues related to particular barriers, incentives, or product categories and to identify priorities for new public investments in the development and evaluation of assistive and accessible technologies. As recommended in Chapter 9, it is also important to undertake research to support coverage decisions for assistive technologies based on evidence of effectiveness.

Recommendation 7.1: Federal agencies that support research on assistive technologies should collaborate on a program of research to improve strategies to identify, develop, and bring to market new or better assistive technologies for people with disabilities. Such research should involve consumers, manufacturers, medical and technical experts, and other relevant agencies and stakeholders.

As noted in this chapter, some helpful steps have been taken to increase government support for technology development and transfer. Funding for the Rehabilitation Engineering Research Centers program, for instance, almost doubled between FY 1999 and FY 2001 but has recently dropped back slightly. Additional research by NIDRR, units of the National Institutes of Health, the National Science Foundation, and other relevant agen-

cies is needed to identify both new technologies and strategies for getting effective products to consumers.

Research into better methods to develop and bring to market effective new technologies needs to extend beyond "high-tech" technologies. Strategies to promote research and commercial development to improve relatively "low-tech" but common equipment, such as walkers, are also important.

Another topic for research is the role of legislation, including existing policies such as the ADA and Section 508 of the Rehabilitation Act, in providing incentives to industry by enlarging the market for accessible technologies. One study that examined patent applications in an attempt to assess the impact of the ADA on assistive technology development found that although references to civil rights laws were not typical in patent records, applications mentioning the ADA increased after passage of the act (Berven and Blanck, 1999). That study, which examined patent applications from 1976 through 1997, found a substantial increase in the numbers of patents related to various kinds of impairments over the entire period but did not note a particular spike after the passage of the ADA.

Accessible Mainstream Technologies

As described earlier in this chapter, public policies have sought to make some mainstream products more accessible, particularly telecommunications and other electronic and information technologies. Some of these policies apply only to government purchases. The ADA focused on reducing certain kinds of environmental barriers and setting standards for the accessibility of buildings, transportation systems, and other public spaces. Although that law and accompanying regulations covered some products that are often installed in buildings (e.g., ATMs), many other mainstream products that are not covered by the ADA or other policies also present substantial barriers to people with disabilities. With an aging population, inaccessible mainstream products will present increasing burdens and costs to individuals with disabilities in the form of reduced independence and reduced participation in the community. This, in turn, will create costs for family members and other caregivers and for society in general. As with the policies discussed in other chapters, further actions to remove barriers and expand access to helpful technologies will have to be assessed in relation to other pressing demands on public and private resources.

Recommendation 7.2: To extend the benefits of accessibility provided by existing federal statutes and regulations, the U.S. Congress should direct the Architectural and Transportation Barriers Compliance Board (the Access Board) to collaborate with relevant public and private groups to develop a plan for establishing accessibility standards for

important mainstream and general use products and technologies. The plan should

- **propose criteria and processes for designating high-priority product areas for standard setting;**
- **identify existing public or private standards or guidelines that might be useful in setting standards; and**
- **include medical equipment as an initial priority area.**

This recommendation proposes a priority-setting process to extend the accessibility policies of the federal government to new product areas. Such a process would take industry concerns as well as consumer and health professional concerns into account and would also consider technical issues in setting standards for different kinds of products. Taking into account the issues discussed in Chapter 6, the committee identified medical equipment as a priority area. It also identified home products and product packaging as particularly important for helping people maintain the most basic levels of independence in activities of daily living. Among the criteria that might be considered in a priority-setting process are the numbers of people likely to be affected by a product and related standards, the potential for standards to improve product accessibility, and the potential for standards to have unwanted effects, such as sharply increasing costs and discouraging innovation.

Increasing Public and Professional Awareness

Discussions of assistive technology generally focus on the development of new and better assistive and accessible technologies and on better insurance coverage. An equal need (also acknowledged in the 1991 IOM report on disabilities) exists to make sure that people with disabilities and those close to them are aware of existing products or product categories, especially products that may not be mentioned or prescribed by health care professionals. Increasing consumer and professional knowledge about assistive technologies should increase the use of the products, which should, in turn, make the market for such products more attractive to private companies, promote greater product diversification, reduce the costs of some products, and generally increase product availability.

The committee believes that a substantial national program to increase the awareness, availability, and acceptability of assistive technologies and accessible mainstream technologies is timely, given the demographic changes in the United States noted earlier in this report. The objectives would be to assist the people with disabilities, family members and friends, and health professionals in learning about (1) the existence and range of potentially beneficial mainstream and assistive technologies and (2) the ways in which

consumers and professionals can obtain additional, up-to-date information about available technologies and products. A campaign can build on the information provision efforts already undertaken by NIDRR and other federal agencies and upon the particular expertise of the Centers for Disease Control and Prevention in developing and managing public and professional awareness programs. In addition, state public health programs are natural partners in developing and implementing an awareness campaign. The campaign can also build on ideas suggested by the National Task Force on Technology and Disability in its draft report (NTFTD, 2004).

Recommendation 7.3: The Centers for Disease Control and Prevention, working with the National Institute on Disability and Rehabilitation Research, should launch a major public health campaign to increase public and health care professional awareness and acceptance of assistive technologies and accessible mainstream technologies that can benefit people with different kinds of disabilities.

Increasing Public Awareness

The consumer component of a public awareness campaign would target not only the lack of knowledge about available technologies but would also help people assess whether they have developed functional deficits for which helpful products exist. The campaign would include guidance for people on

- recognizing their potential needs for assistive technology;
- finding useful information about available technologies and their pluses and minuses;
- identifying and evaluating specific products;
- locating sources of financial assistance; and
- working with health care professionals, suppliers, manufacturers, and others to obtain, maintain, adjust, repair, or replace equipment.

In some cases, people are aware of products but consider them unattractive or stigmatizing, which can be a major barrier to their use. A large-scale, long-term, repetitive public media campaign to increase the acceptance of assistive technologies can highlight what products are available to "make life easier" and convey that it is normal to use smart technologies. Promotions might show celebrities using technologies and natural-looking aids. Another strategy might be to persuade the producers of popular television programs to show the unobtrusive, routine use of assistive technologies. The idea is to help people feel more comfortable using technologies that may allow them to live independently longer or to stay with their

families longer by reducing the amount of informal caregiving needed. If a public awareness campaign identifies unattractive product design as a problem, then that knowledge can also guide contacts with manufacturers and designers about how to modify the products to reduce this barrier to the use of helpful technologies.

Increasing Professional Awareness

In contrast to medications, getting assistive technologies to those who could benefit from them requires more than a physician's prescription. The process also involves the broader spectrum of rehabilitation professionals, such as physical and occupational therapists. Current data suggest that the primary source of information regarding assistive technologies is physicians and other medical personnel (Carlson and Ehrlich, 2005). It also suggests that many people are also unaware of their options.

Nonetheless, in the committee's experience, the lack of awareness by health care professionals (especially those who are not rehabilitation specialists) of the range of assistive technologies and their potential uses is a significant barrier to the wider and more effective use of these technologies. Remedying this lack of awareness will involve efforts on several fronts, including the undergraduate, graduate, and continuing education of health professionals. The committee recognizes that space is at a premium in heavily loaded and tightly structured professional training curricula. Strategies need to be identified to provide quick, interesting, and effective means of injecting information about helpful technologies and methods of assessing consumer needs into education programs.

Health care professionals themselves generally do not need to be experts in the technologies; rather, they need to know, in general, what exists that might help their patients or clients and what basic features of a technology are important for a given patient (e.g., features for people who lack fine motor skills). With this basic knowledge, physicians and other health care professionals may continue their education about particular technologies on their own, designate staff to become resources, or encourage their patients or clients to investigate technologies that do not require a physician prescription or particular professional assistance.

In sum, increasing consumer and professional awareness of useful assistive and accessible technologies should have a positive effect on the use of these technologies and, in turn, on people's functioning and independence. As noted throughout this chapter, the acquisition of useful technologies may be limited by a lack of insurance coverage or other financial access, particularly for people with modest or low incomes. The next two chapters discuss selected issues related to the financing of health care services for people with disabilities.