January, 2003

DEVICE DESIGN

Applying Universal Design to Medical Devices

As more and more complex medical devices are being operated at home, manufacturers need to develop them with disabled users in mind.

Stephen B. Wilcox, PhD

As the trend toward minimizing patient time in the hospital continues, one notable consequence has been the migration of medical devices from medical facilities to patients' homes. This phenomenon means that, increasingly, the patient, rather than the medical professional, is the device user. The effect of this change on the design of many medical products is substantial.

The Personel Lasette from Cell Robotics (Albuquerque) is designed for easy use by people with or without disabilities. (click to enlarge)

Patients and medical professionals could not be more different. Medical professionals are less likely than the general population to suffer from various disabilities and more likely to be above average in the capabilities required to operate medical devices. In contrast, users of home-healthcare devices may suffer from chronic diseases, or experience dexterity or mobility problems; visual, auditory, or other perceptual deficits; or even cognitive disabilities.

From the device designer's point of view, the trend toward home health-care changes the nature of the task. Smart, highly trained users are good at overcoming device limitations, as anyone can testify who has spent time in the operating room or any other area of a hospital. Thus, in effect, the physicians, nurses, and technicians who use medical equipment allow the medical device designer to be a bit sloppy, because the users are smart enough, strong enough, and healthy enough to forgive a multitude of sins. They readily develop work-arounds to overcome the device problems that they face.

Because patients are by comparison much less able to overcome device limitations, there is greater pressure on the designer of a home-healthcare device to reduce those limitations. The designer must assume that the user may have physical, perceptual, or cognitive disabilities. At the same time, no one, the user of a medical device included, wants to be treated as "special" in the sense of "special education." This logic is the impetus for applying so-called universal design to home-healthcare products.

Universal Design

The term universal design was originally coined by the Whirlpool Corp. The idea, also sometimes referred to as inclusive design, is to provide products that are easy for everyone to use, including those with various disabilities. The key is to make a product usable by a person with a dexterity problem or a visual or cognitive deficit, but not to telegraph the fact that the product has been designed for the disabled. Because people do not like to be stigmatized or reminded that they are disabled, they often simply refuse to use an assistive device. As Laura Gitlin puts it, "[A] reason for device abandonment is . . . that devices symbolize a change in competencies that is associated with negative social judgments."[1]

Universal design is a strategy with two parts:

1. To make home-healthcare products appear as normal as possible.
2. To accommodate those with disabilities, who will inevitably be over-represented in the population of users.

The first part is largely a matter of the designer's approach; it does not require special knowledge. Larger text for labels and lower-force control mechanisms, for example, are better for people with various disabilities but they are also easier for everyone to use. The device designer just has to think in these terms, and the incentive structure of the organization has to incorporate the consideration of universal design.

The second part is trickier, because there is a natural tendency for product designers to use themselves as their benchmark user. Thus, when the user is significantly different from the designer, there is a need for the designer to obtain additional information.

What follows, then, is a summary of some of the disabilities from which people suffer and some techniques that device developers can use to help them better understand the needs of disabled users.

Disabilities

According to the U.S. Census Bureau, more than 20% of the general population suffers from some form of disability.[2] The distribution of these disabilities is shown in Figure 1. Fortunately, there are effective design strategies for various conditions.

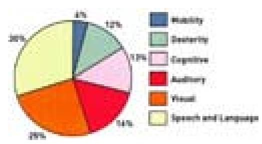

Figure 1. Limitations involving vision, speech, and language make up more than half of all disabilities in the United States.[2]
(click to enlarge)

Mobility / Dexterity. An estimated 1.8 million Americans are in wheelchairs; 13.6 million have limited use of their hands. Difficulty with fine control of the fingers, which is often caused by arthritis, is one of the most common problems. Another common problem is loss of limb control as a result of spinal damage, cerebral palsy, multiple sclerosis, muscular dystrophy, or overuse injuries such as carpal tunnel syndrome.

Some design strategies include making buttons large and widely spaced, so that fine motor control is less necessary and errors less likely. Also, the use of spoken commands for device activation eliminates the need for physical manipulation of controls. Other strategies are to minimize the need for simultaneous actions (so the user will not have to perform two things at once), and the need for sustained pressure on controls (to accommodate people with poor finger or hand strength).

Cognitive. Between 6.2 and 7.7 million people in the United States suffer from mental retardation. Another 510% of the population suffers from learning disabilities. Other cognitive deficits include the mental confusion associated with psychosis, various language problems, and difficulty concentrating, known as attention deficit disorder.

Design strategies for accomodating such users include incorporating automatic rather than user-activated adjustments; the use of simple, unambiguous language; placement of advanced features under a separate menu; making all actions reversible; and avoiding time constraints.

Auditory. Auditory deficits affect 10% of the U.S. population. They vary from total deafness to various levels of partial deafness. The elderly tend to lose higher pitches first.

Design strategies include providing redundant visual or tactile cues for operating information, volume adjustability, and wireless coupling to hearing aids.

Visual. Close to nine million Americans suffer from visual deficits severe enough to make it difficult for them to read an ordinary newspaper. Over half a million people are legally blind. Another common problem is color blindness.

Design strategies include providing tactile landmarks on control surfaces, providing a voice mode redundant to visual information, adding tactile/auditory detents to controls for blind users, and allowing speech as an input mode.

Understanding Disabled Users' Needs

One way for the product developer to understand the needs of disabled users is to obtain technical information about the various deficits--what frequencies of sound are the most problematical, how arthritis affects the hand, etc. There is a great deal of literature on these subjects.[37] Some other strategies are described below.

Including People with Disabilities in the Design Process. A company developing a particular device will probably have access to patients who are likely to use it. However, the problem is to identify the worst cases, so to speak, who may not be contained in a small sample of patients. Thus, it can be useful to recruit people who have particular disabilities. Some methods for doing so include the following:

- Contacting organizations, such as the American Foundation for the Blind or the Arthritis Foundation.
- Placing ads at retail stores that sell assistive devices.
- Contacting the occupational or physical therapy departments of local universities.

Such people can play a number of roles. They can critique designs, participate in brainstorming sessions, or participate in usability testing.

Including Experts in the Design Process. Local universities or organizations can also be used to identify experts in particular disabilities. They can be a rich source of advice.

Creating Heuristic Design Criteria. Accommodating the needs of disabled users can be translated into various objective criteria. Experts can be helpful in developing these criteria, which then can be used as a "filter" to evaluate alternative design approaches.

Simulating Disabilities. A way to give device designers an intuitive sense of what the problems are for disabled users is to simulate disabilities by, for example,

- Wearing blindfolds or translucent glasses.
- Wearing ear plugs.
- Wearing gloves.
- Working from a wheelchair.

Such techniques can provide quick tests for alternative prototypes.

Conclusion

As more medical devices migrate into patients' homes, a universal design strategy becomes more important for making products usable. Successful universal design for these products requires a different approach than the one many medical device companies now use. However, it is a technique that has been widespread for years in the consumer products world, and one that any product development group should be able to learn easily.

REFERENCES

1. J Gitlin, "Why Older People Accept or Reject Assistive Technology," *Generations, Journal of the American Society on Aging* 29, no. 1 (1995): 4146.

2. L McNeil, *Americans with Disabilities*: 1994-95, *Data from the Survey of Income and Program Participation* (Washington, DC: Bureau of the Census Current Population Reports, U.S. Department of Commerce, 1995).

3. J Pirkl, *Transgenerational Design: Products for an Aging Population* (New York: Von Nostrand Reinhold, 1994).

4. Dugan, *Keys to Living with Hearing Loss* (Hauppauge, NY: Barron's Educational Series, 1997).

5. H Kanis, "Operation of Controls on Consumer Products by Physically Impaired Users," *Human Factors* 35 (1993): 305328.

6. H Petrie, "User-Centered Design and Evaluation of Adaptive and Assistive Technology for Disabled and Elderly Users," *Informationstechnik and Techniche Informatik* 39 (1997): 712.

7. G Robertson and D Hix, "User Interface Design Guidelines for Computer Accessibility for Mentally Retarded Adults," *Proceedings of the Human Factors and Ergonomics Society* (Santa Monica, CA: Human Factors and Ergonomics Society, 1994), 300304.

Stephen B. Wilcox, PhD, is the founder and principal of Design Science (Philadelphia).