

Assistive Devices for the Elderly

Harriet Kaplan*

Abstract

This article presents a review of assistive technology as it applies to elderly hearing-impaired people living independently and in group environments. Listening systems for personal communication and large area amplification, telephone, and television use are described. Visual systems that can be used to meet the communication needs of elderly persons and alerting systems are included. Issues that must be considered in the selection of personal and large area listening systems are discussed.

Key Words: Alerting devices, assistive devices, elderly, hearing impaired, large area amplification, listening systems, presbycusis, telecommunications

Successful use of hearing aids by older adults is sometimes impacted by special problems related to the nature of presbycusis. These problems are especially prevalent among elderly people over age 85, particularly those living in institutional settings (Davies and Mueller, 1987; Stach and Stoner, 1991). In a survey of nursing home patients, Schow (1982) reported that only 33 percent used hearing aids.

The physical nature of age-related hearing loss can interfere with use of amplification. Presbycusis frequently involves dysfunction of the central auditory pathways as well as the cochlea, resulting in severe word recognition problems in the presence of competing noise, speech, or reverberation (Goetzinger et al, 1961; Kirikae, 1965; Jerger, 1973; Orchik and Burgess, 1977; Bergman, 1980; Gulya, 1991; Stach and Stoner, 1991). Stach et al (1990) investigated the prevalence of central presbycusis in the elderly population, attempting to control for peripheral hearing loss. They found that the presence of speech audiometric abnormalities increased from 58 percent in the 65- to 69-year-old group to 95 percent in the group over 80 years of age.

Most hearing aids, even those that are programmable, use directional microphones or have special circuitry and are of limited benefit under

conditions of noise and reverberation. They might be useful to individuals with central presbycusis in quiet situations involving one-to-one communication, but are often of little value for group communication, distance listening, in reverberant rooms, or in background noise. A number of studies have shown that hearing aid performance declines with increasing amount of central presbycusis (Surr et al, 1978; Hayes and Jerger, 1979; Brooks, 1985; Stach et al, 1985).

The number and age range of elderly Americans are increasing. According to American Association of Retired Persons' data (Fowles, 1993), there were 10.6 million people between age 75 and 84 and 3.3 million over age 85 in 1992. Increasing age variation is accompanied by increasing variation in physical and mental capabilities and living arrangements. The "young-old" (age 65 to 85) group tends to be similar in many ways to people under age 65, except that work-related communication is no longer an issue for most. The "old-old" (over 85) group tends to demonstrate more health problems (e.g., arthritis), reduced mobility, cognitive problems, and difficulty with one or more activities of daily living (U.S. Bureau of the Census, 1992; Fowles, 1993).

Increasing disability tends to be accompanied by more institutionalized forms of living. Living arrangements of older Americans vary from independent living, alone or with a spouse, to home care to varying forms of communal arrangements such as assisted-living communities and nursing homes. Elderly individuals who are cared for by family members often

*Department of Audiology and Speech Language Pathology, Gallaudet University, Washington, DC

Reprint requests: Harriet Kaplan, Department of Audiology and Speech Language Pathology, Gallaudet University, 800 Florida Ave., NE, Washington, DC 20002

participate in adult day care, and able-bodied independent living elderly frequently attend senior citizen centers.

Assistive listening devices (ALDs) can be very useful for difficult communication situations such as meetings, lectures, places of worship, theatres, or television, either in conjunction with a hearing aid or as a substitute. When listening systems do not meet needs, elderly hearing-impaired people can benefit from visual and vibrotactile systems such as captioning, telecommunication devices for the deaf (TDDs),* and flashing or vibrating alerting devices. Assistive devices can be useful for independent living elderly as well as those in more institutionalized settings, but what is recommended must reflect the specific communication needs and capabilities of the individual. The purpose of this article is to present an overview of assistive technology useful for elderly hearing-impaired individuals and discuss their applications to different categories of older individuals and different types of residential and day facilities in which they participate. More detailed reviews of these technologies may be found in the following publications: Kaplan, 1987; Compton, 1991a, 1993; Vaughn and Lightfoot, 1992; Lewis, 1994a, b; and Ross, 1994b.

ASSISTIVE LISTENING DEVICES

Assistive listening systems consist of technology to assist with face-to-face communication, broadcast media (radio, stereo, television), and use of the telephone. Assistive listening systems can overcome the communication problems created by background noise, reverberation, and distance listening by use of the remote microphone that is placed within 3 to 6 inches from the sound source. Once the speech enters the microphone, it is processed in such a way that there is no attenuation of the signal. Because room noise must travel through the air, it is significantly attenuated by the time it reaches the listener. Therefore, the signal-to-noise ratio is increased and the problems created by background noise, reverberation, and distance listening are overcome. In contrast, the hearing aid microphone is located at the ear of the listener; both speech and noise are attenuated as they travel through the air and may

enter the hearing aid at the same intensity level, resulting in confusion.

Most ALDs can be used without a hearing aid; instead, earphones, earbuds, or a button-type receiver coupled to an earmold custom made for the individual can be used. Therefore, ALDs may be used by elderly clients who do not wear hearing aids but can benefit from listening enhancement for specific purposes such as television or church. For example, a nursing home resident who cannot benefit from hearing aids because of severe word recognition problems might benefit from an FM system used with the television in her room. The microphone of the system would be connected to the TV loudspeaker and the FM receiver to earphones.

All ALDs can interface with hearing aids in several ways. The most common interface is a neckloop, which is a small cable plugged into the ALD and worn around the neck (inductive coupling). The signal from the ALD outputs to the neckloop, from which it is transmitted in the form of electromagnetic energy. The hearing aid telecoil picks up the electromagnetic energy from the neckloop. Figure 1 shows ALDs connected to a neckloop.

Unfortunately, telecoil performance has been less than optimal in many hearing aids, particularly in some in-the-ear (ITE) instruments. The coils have not been sufficiently powerful, resulting in narrow frequency responses, high levels of distortion, and insufficient volume. Telecoils are available for both behind-the-ear (BTE) and ITE instruments that provide additional preamplifier circuits, oversized cores, or additional wiring in the coil. Such telecoils can provide up to 25 dB of additional power than conventional telecoils and frequency responses similar to those occurring with the microphone (Compton, 1991b; Ross, 1994a).

When the hearing aid telecoil is activated, the hearing aid microphone is usually turned off. Many hearing aids, however, provide a microphone/telecoil (MT) switching option to allow both microphone and telecoil to remain active. In that way, the user can receive the signal from the ALD and also important environmental sounds, should they occur. For example, a client using an inductively coupled ALD to listen to television might also want to hear the doorbell or the telephone ringer through the microphone circuit. In addition, the MT feature allows the listener to hear comments from the audience at a lecture or meeting as well as the voice of the speaker. Many older adults attend classes, lectures, or meetings of organizations.

*The terms TTY, TTD, and TT (teletext) are used interchangeably.

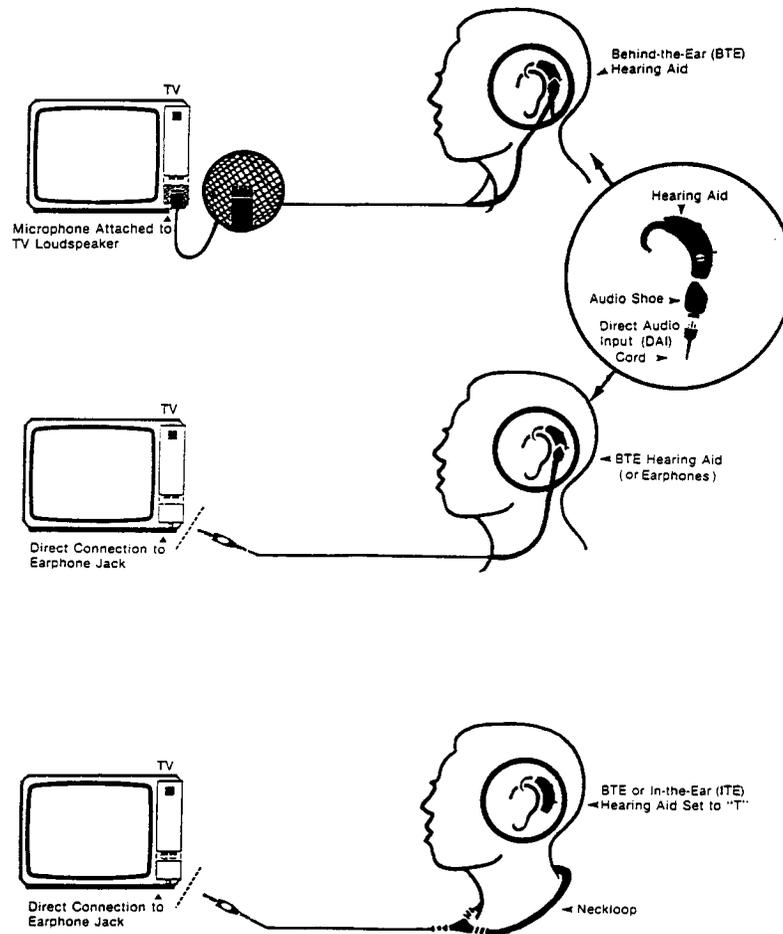


Figure 1 Use of hearing aid dependent hardwired systems with television. From *Assistive Devices: Doorways to Independence* by CL Compton (1991b). Reprinted with permission.

A silhouette conductor may be used instead of a neckloop. A silhouette is a flat hearing aid shaped plate containing a small embedded loop of wire, which is placed between the person's mastoid bone and surface of a BTE hearing aid. The plate is connected to the ALD by a cord. Electromagnetic energy emanating from the induction loop in the silhouette is picked up by the hearing aid telecoil. The silhouette is an option only with a BTE hearing aid. With the ITE instruments preferred by most elderly hearing aid users, the neckloop is the only possible option for inductive coupling.

Another way to interface an ALD with a hearing aid is by using direct audio input (DAI). DAI systems are available with all BTE and some ITE hearing aids either as a standard feature or a fitting option. The ALD plugs directly into the hearing aid via a cord and special audio shoe, allowing the signal to bypass the hearing aid microphone and go directly to

the hearing aid amplifier. As with inductive coupling, hearing aid switching options can be ordered so that the user can turn off the microphone or allow both environmental and ALD signals to be heard. Generally, the hearing aid is designed so that when the microphone is active, the signal from the ALD is more intense. In most cases, each brand of hearing aid must be used with its own audio shoe and cord.

Personal Listening Systems

Personal listening systems use two technologies, FM and hardwire. A system is considered to be used for personal listening when it is used for face-to-face communication between a hearing-impaired individual and one or several talkers. Usually, a personal listening system is owned by a hearing-impaired individual rather than a facility.

FM Systems

An FM system involves a microphone/transmitter to pick up speech or other sound and transmit it to the listener using a frequency-modulated (FM) radio wave. The listener wears an FM receiver that demodulates the signal, amplifies it, sometimes shapes it acoustically, and delivers it to the ear via earphones or the personal hearing aid. The FM transmitter used by the talker and the FM receiver worn by the listener resemble body-worn hearing aids.

The FM transmitter and receiver must be tuned to the same radio frequency or channel. Federal Communication Commission (FCC) rules allow the use of 10 wideband and 40 narrowband channels on a frequency band between 72.025 MHz and 75.975 MHz for communication purposes. Both wideband and narrowband systems are available. When several communications are occurring in close proximity, each one must use a different channel to avoid interference. With most applications, the FM transmitter channel is fixed. The receiver channel can be changed by manipulating a switch or changing plug-in crystals, allowing a single receiver to be used with a variety of transmitters. Less expensive systems have been developed for adult use in which both the transmitter and receiver use only one channel. The complexity of a personal system depends on the capabilities and communication needs of the user. For example, an older individual who uses a personal FM system for television and one-to-one communication in the home can probably function well with a single-channel system. If, however, the client also wishes to use the FM receiver in theatres offering FM amplification, the receiver must have the capability of switching channels.

Most FM systems designed for adults do not include built-in hearing aids because adults frequently interface their systems with their personal hearing aids, which provide environmental microphones. If an FM system, however, is to be used with earphones rather than a personal hearing aid, it is desirable for the FM receiver to include an environmental microphone.

A new FM system that incorporates a BTE hearing aid in the FM receiver has recently been introduced. It provides switching options that allow the listener to use it as a personal hearing aid, an FM unit, or an FM with an environmental microphone. The BTE FM is an important innovation because of its increased cosmetic acceptability and its convenience for users who require both an ALD and a personal hearing aid.

FM systems (one microphone/transmitter and one receiver) are perhaps the most versatile of all ALD technologies. The transmission range of personal FM is approximately 150 to 200 feet. FM technology can be used indoors or outdoors, in large areas or small groups, or with radio or television.

An elderly hearing-impaired person can use a personal FM system in a variety of situations. One-to-one communication at home, in a senior citizen center, in a hotel, or while visiting physicians, lawyers, or religious counselors can be facilitated if the hearing aid alone is not adequate. The FM signal can travel through walls, allowing easy communication from one room to another. The microphone/transmitter of the personal FM system can be used by a tour guide to increase the enjoyment of travel. Interpersonal communication in a car can be facilitated by dangling the microphone over the back of the front seat to pick up the voices of passengers in the rear. The same personal FM system can be used for television listening by placing the microphone/transmitter near the TV loudspeaker.

The concept of "self-wiring," introduced by Vaughn and Lightfoot (1983), is an alternative in some situations to asking the talker to wear or hold a microphone. The hearing-impaired person wears the microphone and transmitter on clothing and stands close to the talker, maximizing the intensity level of the talker's voice at the microphone. This technique can be useful for one-to-one communication in a noisy environment where speaker and listener are in close proximity to each other.

FM systems can be useful for lectures or religious services during which the talker wears the microphone. During a lecture, however, other strategies are necessary for the listener to hear questions or comments from the audience. The listener may use the environmental microphone, wear a hearing aid in the ear not receiving the FM signal, or ask the talker to repeat all audience comments.

In order to use an FM system for a lecture, meeting, or religious service, the elderly client must be willing to ask the talker to use the FM microphone/transmitter. Some elderly people feel uncomfortable about making such requests and require counseling or assertiveness training to facilitate communication in these situations.

FM may be used for small group communication in a restaurant, at a small meeting, or dinner party. In such situations, the microphone may be passed from talker to talker. Many people dislike making such a request, particularly

because passing a microphone may interfere with the spontaneity of conversation. As an alternative, a pressure-zone microphone placed in the middle of a small table will work well as long as people take turns talking and the room is relatively quiet.

Many of the "young-old" hearing-impaired elderly engage in these activities. Stach and Stoner (1991) have been recommending personal FM units with or without hearing aids for their elderly clients, and report positive changes in their quality of life. Personal FM systems can also be useful in nursing homes, adult day care centers, and retirement communities for lectures; visits from physicians, religious counselors, and family members; television listening; or the dining room.

Hardwire Systems

Hardwire systems involve direct connection via cord between the sound source and the listener. Some hardwire systems use a microphone to pick up speech while others use a direct plug-in connection to a radio or television. With the hardwire system, the mobility of the listener is restricted to the area defined by the length of the cord. If mobility is not an issue, as with a bedridden patient at home or in a long-term care facility needing to communicate with visitors, a hardwire system can provide the same benefits as an FM system. Hardwire systems are sometimes preferable to FM for one-to-one communication or television listening in nursing homes because they are simpler and significantly less expensive than FM. They are more likely to be managed by multiply disabled elderly individuals than either personal hearing aids or wireless systems. Dempsey (1994) reports on several studies demonstrating successful use of hardwire ALDs with cognitive- or language-impaired adults with hearing loss.

Figure 1A shows a hardwire system with a microphone attached to an amplifier that is connected to the hearing aid via DAI. Figure 1B shows a system that plugs directly into the television (or radio or stereo), does not require a separate amplifier, and DAIs to the hearing aid. The system in Figure 1C plugs directly into the television and attaches to a neckloop. The signal is picked up by the hearing aid telecoil. The systems shown in Figures 1B and 1C can be used with a microphone instead of the direct plug connection. All of the hardwire systems can be used with earphones instead of a hearing aid.

Elderly people living in long-term care facilities tend to have more restricted lives than those living more independent lives. There may be visual and cognitive problems and difficulty manipulating small devices because of arthritis and reduced tactile sensation. Hearing aid use may not be feasible because of central auditory processing problems and/or inability to handle the earmold or the controls. Simple hardwire systems with earphones may be a good solution for communication problems. When a visitor wishes to communicate, she simply puts the earphones on the elderly individual, turns on the system, and talks into the microphone. The same system can be used with the radio, stereo, or television, provided that the extension cord is long enough for comfortable viewing. In the dining room, the microphone can be placed near the talker. When there are multiple talkers, however, the microphone must be passed from talker to talker. The microphone can be attached to a public address system loudspeaker used during religious services.

The quality of the amplified signals of commercial hardwire systems varies considerably. Manufacturers generally do not provide electroacoustic specifications for their systems. Dempsey and Ross (1992) evaluated a number of systems electroacoustically and found wide variability in frequency response and amount of gain. None of the systems demonstrated broad, flat, wideband responses, even when coupled to hearing aids. There was no clear relationship, however, between subjective evaluation of speech intelligibility or quality by hearing-impaired adults and power, frequency response, or cost of the systems. All systems were rated highly in ease of use (Dempsey and Ross, 1991). Perhaps more objective protocols of fitting these systems are needed.

Although hardwire ALDs should not generally be considered a substitute for the personal hearing aid, they may be considered the amplification system of choice for use in specific situations by multiply disabled elderly individuals who cannot use hearing aids.

Visual Interactive Communication

Sometimes elderly adults have difficulty understanding at meetings and lectures with any kind of listening system. Communication can be facilitated in these situations by writing notes on large paper mounted in front of the room or on a transparency placed on an overhead projector. Alternatively, information may be

transferred onto a transparency in advance of the lecture and projected onto a screen in synchrony with the talker's presentation.

A "higher tech" version of the note-taking concept is called computer-assisted note taking. A person with good typing and note-taking skills uses a keyboard to enter, into a computer, notes based on an ongoing presentation. What is typed appears on a projection panel as a liquid crystal display and is then projected onto a screen. If desired, the text may be made available later as hard copy. Computer-assisted note taking is being used at meetings of hearing-impaired adult groups that usually include older adults (Virvan, 1991). It is also regularly used during classes at the Gallaudet University Aural Rehabilitation Elderhostel programs.

For those hearing-impaired elderly individuals who cannot use the telephone auditorily, TDDs are available. The telephone receiver is placed into an acoustic modem or the TDD is connected directly to the telephone line. Both communicators must use TDDs, which have typewriter-type keyboards and LED displays. Each communicator types a message on the keyboard, which is transmitted via the telephone lines and appears in printed form on the LED screen. If a call needs to be made to someone who does not have a TDD, dual-party relay systems are available that involve the use of a communication assistant who acts as an intermediary between the TDD and voice phone.

Although TDDs traditionally have been used by deaf people, elderly hard-of-hearing individuals with poor word recognition skills might consider their use. Long-term residential and daycare facilities need to make TDDs available for those residents or clients who can benefit.

Television/Radio Access Systems

A large number of hearing-impaired elderly people experience difficulty hearing and understanding the television. Increasing the volume often increases distortion rather than improving the clarity of the signal. Interference from background noise and reverberation presents problems in long-term care facilities, adult day care centers, and even private homes. Day rooms in retirement communities, nursing homes, or adult day care centers tend to be noisy, reverberant places. Finally, the volume required by a hearing-impaired person may interfere with the comfort of others in the same room or adja-

cent rooms, creating conflict within a family or between neighbors.

There are a number of assistive listening systems that can overcome or minimize these difficulties. All of the technologies described for interpersonal listening can be adapted to television or radio. With hardwire, FM, or infrared systems, a microphone may be placed near the television loudspeaker and connected to a transmitter, amplifier, or directly to earphones or a hearing aid. The volume control on the television is adjusted for the normal-hearing individual and the hearing-impaired listener adjusts a volume control on the ALD amplifier, receiver, or hearing aid.

It is possible to plug a listening system directly into the earphone jack of a television instead of using a microphone. Signal fidelity is sometimes improved in this way by eliminating the distortion present in the television loudspeaker or ALD microphone. With most televisions, however, direct connection eliminates the loudspeaker, making it impossible for more than one person to watch television at the same time. The direct connection option may be desirable if an individual wishes to watch television or listen to the radio without disturbing other family members or others in a long-term care facility.

A special application of FM is the TV band radio, which contains frequency bands used for television transmission. The listener tunes in the television channels and controls the volume on the radio, which can output to earphones or a hearing aid via neckloop, silhouette, or DAI.

Small infrared transmitters have been designed for television use; they connect to microphones that pick up the signal from the television loudspeaker. The signal is transmitted via infrared carrier waves and picked up by infrared receivers. Small, inexpensive audio loops are available for TV use. Either the room or the television area may be enclosed by the cable.

For those people who find television listening systems unsatisfactory, closed captioning can be very helpful. Although closed captioning has been traditionally used by deaf people, it can be very useful for hard-of-hearing people who experience severe word recognition problems. The Television Decoder Circuitry Act of 1990 (PL 101-431) requires that all new televisions with screens 13 inches or larger must contain decoder circuitry. Since the law does not require older televisions to be retrofitted, separate decoder boxes are needed. Clients and administrators of long-term care and day care facilities need to be made aware of this option.

Alerting Devices

Alerting devices are electronic systems that monitor important sounds in the home such as the telephone ringer, the doorbell, the door knocker, the alarm clock, or emergency signals such as a fire or a smoke alarm. These systems can also monitor a person in another room who might be bedridden or mobility impaired. Alerting devices can facilitate independent functioning for elderly hard-of-hearing individuals in the home, day care center, or senior citizen center. For example, when an elderly hearing-impaired individual is living alone, security is important. Alerting devices increase safety by making the older person aware of the doorbell, the telephone ringer, and the smoke alarm. Awareness of the smoke or fire alarm is equally important in the day care facility. In addition, in the long-term care facility, alerting devices allow a nurse or aide to monitor the needs of residents and provide visible or tactile warning signals in case of emergency.

Alerting devices pick up the monitored sound through microphones or direct electrical connection. The signal is transmitted to receivers either through hardwired or wireless technology. Systems are powered by batteries or line current. With wireless technology, it is possible to pick up a signal (e.g., doorbell) and transmit it to receivers in one or more remote locations (e.g., kitchen and bedroom). Alerting stimuli include bright incandescent light, strobe lights, vibrators (e.g., bed shakers or pagers), and loud or low-pitched auditory signals.

Further discussion of alerting devices can be found in Jensema and Lennox (1994).

SELECTION OF APPROPRIATE DEVICES

There are many assistive devices on the market and new systems and modifications are appearing continually. Elderly clients need assistance from professionals to select the technology that is most appropriate for their communication needs and capabilities. Because long-term care facilities must be in compliance with the requirements of the Americans with Disabilities Act, administrators need guidance from aural rehabilitationists as to which large area systems best meet the needs of their residents.

The fitting of personal assistive listening systems should be within the context of overall audiologic management. Degree of hearing loss,

word recognition ability, use or nonuse of hearing aids, and features of hearing aids (e.g., telecoil or DAI) influence the ALD system recommended. If the elderly person is in the process of acquiring a new hearing aid, features that allow interface with assistive listening systems should be considered. After selection of assistive listening systems has been completed, training and orientation in their use is essential for elderly clients and significant others.

Analysis of communication needs based on an elderly person's lifestyle is crucial to selection of optimal technology. The client's interpersonal, telephone, and alerting needs in the home, while traveling, and in recreational situations need to be analyzed. The goal is to find the least expensive, most versatile, and most durable system that will address the majority of the elderly client's communication problems.

Compton (1993) provides an excellent discussion of the needs assessment process and its relationship to selection of assistive technology. She talks about communication needs in the home that might include one-to-one conversation, group conversation (e.g., at dinner), telephone communication, television reception, and monitoring of the doorbell, telephone ringer, children's activities, smoke alarm, and appliance signals. The needs of family members (e.g., whether the elderly client watches the television alone or with others) influence the type of system selected.

Communication needs in a group home may involve conversation in a day room or a dining room, television viewing, use of the telephone, ability to hear in an auditorium or chapel, and the ability to communicate with caregivers. Awareness of warning signals are as important in this environment as in the family environment.

Recreational and travel communication needs include one-to-one or small group communication in a hotel, restaurant, class situation, lecture hall, or tour. Telephone communication at pay phones, hotels, or airports and awareness of warning signals in these facilities are equally important. Portability and mobility of systems, as well as the ability to use personal devices with large area systems, become important concerns. Recreational and travel communication needs are important concerns for elderly people. Large numbers of older adults have the financial ability and interest to travel and participate in active leisure activities.

CASE ILLUSTRATION

The following case illustrates the importance of assistive devices in the life of an elderly hearing-impaired individual. Mr. Smith is an 80-year-old man who has had a progressive hearing loss for the past 30 years. Although he has used hearing aids for many years, their communicative benefits have gradually declined and his dependence on his wife has gradually increased. In recent years, he relied on her to help him understand conversation in group situations, handle all telephone communication, and make him aware of important environmental sounds such as the doorbell or alarm clock. As his hearing loss progressed, their social life became more limited. When Mr. Smith's wife died several months ago, his children began to consider a long-term care facility. Mr. Smith, however, had no other health problems and wished to maintain his independence. He decided to visit an audiology facility to find ways to maintain himself in his home.

After completion of a hearing evaluation, new hearing aids and a variety of assistive devices were recommended. Although the new hearing aids improved his ability to understand face-to-face conversation in a quiet situation, understanding speech in noise, group situations, and on the telephone and the television still presented problems. In addition, he was unable to hear environmental sounds outside of his immediate location.

Mr. Smith was fitted with an FM system, which he used with one of his hearing aids via DAI. This allowed him to communicate in group situations, particularly family gatherings, and facilitated television listening and communication in the car. He began to attend programs at the local senior citizen center because his FM system made it possible to hear lecturers, the program director, and other older adults at the center. He also joined a senior citizen advocacy/support group where he was introduced to computer-assisted note taking.

Mr. Smith decided to purchase a new television with a built-in decoder chip so that he would have the option of using closed captions. Since comfortable telephone communication was not possible with his hearing aids or with telephone amplifiers, he purchased a TDD and learned to use a telephone relay system. This allowed family and friends to maintain close contact with him, alleviating concerns about his safety. Finally, alerting devices were installed in Mr. Smith's home to allow him to monitor the

doorbell, the telephone ringer, the alarm clock, and the smoke alarm. With the help of assistive technology, Mr. Smith continued to live comfortably and independently in his home.

SUMMARY

Assistive devices constitute an important part of the rehabilitation of hearing-impaired older adults. Listening systems can facilitate understanding of speech in noise, reverberation, and distance listening situations, which many hearing aids do not handle well. Telephone and television reception can be improved by either auditory or visual assistive technology. Alerting devices can provide increased independence and safety within the home. Aural rehabilitationists need to become conversant with the various technologies that can be used for personal listening situations so that appropriate systems can be recommended to elderly hearing-impaired individuals. Professionals are increasingly being asked to help administrators of long-term care facilities, day care centers, and senior citizen programs improve communication access for their clients and to keep them in compliance with ADA.

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