



Personal Sound Amplifiers for Adults with Hearing Loss

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ABSTRACT

Age-related hearing loss is highly prevalent and often untreated. Use of hearing aids has been associated with improvements in communication and quality of life, but such treatment is unaffordable or inaccessible for many adults. The purpose of this review is to provide a practical guide for physicians who work with older adults who are experiencing hearing and communication difficulties. Specifically, we review direct-to-consumer amplification products that can be used to address hearing loss in adults. Helping adults with hearing loss navigate hearing loss treatment options ranging from being professionally fitted with hearing aids to using direct-to-consumer amplification options is important for primary care clinicians to understand given our increasing understanding of the impact of hearing loss on cognitive, social, and physical functioning.

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Hearing loss in older adults is highly prevalent and doubles per age decade, with onset beginning as early as one's 40s or 50s. Age-related hearing loss begins gradually and can progress for years before an individual begins to experience subjective hearing difficulties. Further, hearing complaints tend to initially manifest in difficult listening situations, such as group discussions at work or conversations in a noisy

setting, like a restaurant. The gradual progression and common occurrence of age-related hearing loss leads many individuals with communication difficulties, as well as medical providers, to treat hearing loss as a normal and inconsequential part of aging. However, a growing body of evidence suggests that age-related hearing loss may directly contribute to an increased risk of cognitive¹⁻³ and physical declines.^{4,5}

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Over two-thirds of adults aged > 70 years (~30 million Americans) have a clinically significant hearing loss.⁶ With increasing evidence of independent associations between hearing loss and negative outcomes among older adults, such as accelerated cognitive decline,³ decreased physical functioning,⁷ increased hospitalization,^{8,9} and mortality,¹⁰ the provision of hearing health care has been raised as a possible low-risk intervention that may delay these outcomes and promote healthy aging.^{11,12} Hearing aids, along with education and counseling, form the foundation of intervention for age-related hearing loss. However, < 20% of persons with hearing loss use hearing aids.¹³ From a public health perspective, the low rate of treatment for age-related hearing loss underscores the need for new approaches to the provision

of hearing technologies and services in order to reduce the gap between those with hearing loss and those who are able and willing to access care.

Numerous barriers limit access to hearing health care, particularly the high cost of hearing aids (average cost is \$3000-6000 for a pair¹⁴), and lack of coverage by Medicare and other insurance companies.¹⁵

Another impediment to accessing care is that the patient must visit the audiologist 4 to 6 times over a 4-month period to be properly assessed and fitted with customized technology. Despite the associated cost and required commitment, hearing aid use has been shown in multiple studies to improve communication and quality of life.¹⁶⁻¹⁸

Due to the positive outcomes associated with treating hearing loss and the prevalence of age-related hearing loss among older adults, the National Institutes of Health/National Institute on Deafness and Other Communication Disorders and the Institute of Medicine have called for increasing the affordability and accessibility of hearing health care.^{12,19}

One step toward improving the affordability and accessibility of hearing health care is to consider the utility of low-cost amplification devices that can be directly purchased by consumers rather than having to be dispensed and fitted by an audiologist or hearing instrument specialist. The purpose of this review is to provide an introduction to the use of direct-to-consumer hearing devices as communication options for adults with hearing loss who are not ready to undergo formal audiological services, or who are unable to afford hearing aids. The 3 sections of this review will provide practical guidance and tools that can be discussed with patients who have hearing complaints in order to enhance communication and social engagement. The first section summarizes what to expect from best-practice professional audiology services and professionally fitted hearing aids. The second section describes the types of hearing devices that are available to consumers and important technological and user features that make devices most appropriate for some persons with age-related hearing loss. Finally, the third section focuses on considerations for older adults that may guide recommendations for accessing professional hearing health care or improving communication using over-the-counter technologies.

PROFESSIONAL AUDIOLOGY SERVICES

Professional audiology services provide a customized approach to addressing a person's hearing loss with hearing aids (and other technology as necessary) prescribed in response to an individual's listening needs and lifestyle. The

role of the audiologist is to first perform comprehensive diagnostic services and make appropriate medical referrals when needed. Then, an audiologist should perform an in-depth needs and lifestyle assessment to customize the amplification device to a person's hearing loss and listening needs. In terms of technology, the most frequently used

devices are programmable hearing aids that are precisely tuned to the individual's hearing loss. Hearing loss is typically not the same across all the sounds important for human hearing. For age-related hearing loss, it is most common for patients to hear low-frequency sounds (eg, "ah" as in "father") better than they can hear high-frequency sounds (eg, "s" as in "toss"). Importantly, a professionally fitted hearing aid can be programmed such that the volume at different frequencies is specifically adjusted to match the hearing loss of each individual.

A key component of successful audiology services is to educate the person with hearing loss and

loved ones to ensure appropriate expectation management that entails use of amplification in conjunction with communication strategies to improve listening across a range of situations. Audiologists have completed doctoral-level training on the diagnosis and treatment of hearing loss, which includes skills related to counseling patients on how to cope with their hearing loss and manage daily communication challenges. Traditionally, the price of the services provided by the audiologist, both before and after fitting hearing aids, are bundled into the price of the hearing aids and can comprise 40%-70% of the total cost charged to patients (ie, for a \$5000 pair of hearing aids, approximately 2/3 of the cost actually covers an audiologist's time and services). While professional aural rehabilitation provided by the audiologist offers a "gold standard" approach to treating hearing loss, the traditional model remains unaffordable and inaccessible to many individuals. Importantly, some individuals may not require the comprehensive set of services that an audiologist would provide and that is "bundled" into the cost of professionally dispensed hearing aids regardless of patient need.

CLINICAL SIGNIFICANCE

- Two-thirds of adults > 70 years have a clinically significant hearing loss, and hearing loss may directly increase risk for cognitive decline and dementia.
- The high cost (~\$4000 for a pair of hearing aids) and inconvenience (multiple visits needed for fitting and adjustments) of hearing health care limits access for many older adults.
- Certain direct-to-consumer amplifier products can be a helpful, affordable, and accessible initial option for addressing hearing.

DIRECT-TO-CONSUMER AMPLIFICATION

While traditional hearing aids remain unaffordable for many people, the increasing market for consumer electronics and wearable technology (in this case, personal sound amplifiers), presents new opportunities for "do-it-yourself" amplification. The landscape of consumer electronics as it relates to hearing devices is difficult to navigate. From a technology standpoint, both hearing aids and personal sound amplifiers are designed

to amplify sound. However, from a policy standpoint, hearing aids are designated as class I or II medical devices by the US Food and Drug Administration (FDA) and are intended to treat medically diagnosed hearing loss. On the other hand, personal sound amplifiers are not FDA-regulated, and are marketed as “communication enhancement” devices. For the consumer, this distinction generally means that hearing aids must be sold by a licensed professional (regulated by state), and personal sound amplifiers can be sold over the counter. A caveat is that Internet sales often do not fall under the purview of state regulations, and so, there are many “self-fit” hearing aids available directly to the consumer via the Internet. For the purpose of this review, both FDA-approved self-fit hearing aids available via the Internet and personal sound amplifiers (ie, non FDA-approved amplifiers) will be referred to as “direct-to-consumer hearing devices.”

The focus of this discussion will be on the technological characteristics of direct-to-consumer hearing devices in order to inform primary care clinicians about how to help patients seeking solutions for their hearing loss but not wishing to pursue formal audiological evaluation. Previous studies have examined the acoustic properties of low-end hearing devices (ie, cost \$10-80) and have shown limited benefit.^{20,21} However, to our knowledge there has been no audiological research assessing the technical quality of the newer generation of hearing devices that comprise a higher price point (ie, cost \$200-400) of the direct-to-consumer hearing device market.

Due to the increasing availability of direct-to-consumer hearing devices via Internet sales and the continued widespread lack of treatment among adults with hearing loss, we undertook a technical evaluation of a sample of direct-to-consumer hearing devices to determine if these hearing devices could provide suitable amplification for the average adult with some hearing complaints. In-depth electroacoustic analysis of the tested devices (n = 12) is available in a companion paper.²² The findings presented here represent practical information on how to provide guidance to patients with complaints of hearing loss or communication difficulties who may be interested in the “do-it-yourself” approach.

TECHNICAL CHARACTERISTICS OF AMPLIFICATION PRODUCTS

The purpose of this section is to define some of the important sound-processing features of amplification devices to better understand what qualities are important for patients when choosing a hearing device, along with recommendations for the top 5 devices in our test sample that were likely to provide the most benefit to the average adult user.

Appropriate Output

Age-related hearing loss generally affects low and high frequencies differently, with high-frequency hearing loss significantly more common in older patients. The result of this

frequency-specific hearing loss is the common complaint, “I hear you—I just don’t understand you.” Often, with age-related hearing loss, the individual continues to have good hearing for low-frequency sounds, which in speech include robust vowel sounds like “ah” (“father”). Meanwhile, soft, high-frequency speech sounds, such as “th” (“bath”), “f” (“fat”), “s” (“toss”), become inaudible. Consequently, one hears the words but they lack clarity. Earlier generations of self-fit hearing devices typically provided too much amplification for low-frequency sounds (ie, in the region that many people still have good hearing) while offering little to no amplification for the high-frequency sounds (ie, the sounds necessary to improve speech clarity). To appropriately meet the needs of persons with age-related hearing loss, devices must use multiple-channel processing so that amplification can be provided in different amounts at different frequencies. We analyzed the frequency-specific gain for each product and compared them with prescriptive targets commonly used in audiology for best speech understanding. **Table 1** indicates whether each device was appropriate for an adult with typical age-related hearing loss.

Signal-to-noise Improvement

To enhance speech understanding, the listener needs the difference between speech and background noise, known as the signal-to-noise ratio, to become more extreme. One common hearing aid approach is to improve the signal-to-noise ratio through directional microphones that turn up the sound in front (ie, the person speaking in front of you) and minimize sounds from the back (ie, background noise.) As hearing aids have advanced, the directionality feature has become more flexible than front-to-back, with some models of hearing aids that are able to automatically adjust as the noise in the environment changes location. Another approach to improving signal-to-noise ratio is to use a remote microphone that is separate from the hearing aid and may be set on a table near the person speaking or used as a lapel microphone. This type of remote microphone system can be integrated with hearing aids or used as a stand-alone device. A third approach that is useful in venues equipped with “loop systems” is an integrated t-coil that provides direct amplification from the sound system to the hearing device (for more information, see www.hearingloop.org). In addition, t-coils allow for direct connection and improved listening on landline telephones. Lastly, some devices attempt to improve signal-to-noise ratio by providing a boost to the frequencies that carry the most speech information and use algorithms that recognize speech and enhance this sound more than other sounds. The hearing devices reviewed here include a variety of speech enhancement options (**Table 1**).

Listening Comfort

A common complaint of hearing aids is that everything becomes too loud. To varying degrees of success, hearing aids have algorithms that try to determine if a sound is

Table 1 Recommended Direct-to-consumer Hearing Devices and Key Technological and User Features

	Bean T-Coil	CS-50+	Tweak Focus	Soundhawk	Songbird
					
Frequency Output	● Too much low frequency gain	✓ 1. Within prescribed targets 2. Smartphone programming matches gain to hearing loss	✓ Within prescribed targets	✓ 1. Within prescribed targets 2. Customize gain preferences with Smartphone	✓ Within prescribed targets
Signal-to-Noise Ratio	● T-Coil feature	✓ 1. Directionality setting 2. Speech enhancement software	● Directionality	✓ Remote microphone	✗
Listening Comfort	✗	✓ Noise reduction processing	● Low internal noise	● Low internal noise	● Low internal noise
User Features	● User manual only	✓ 1. User videos on Sound Word Solution's Web site 2. Large rechargeable battery	✓ DVD with: 1. User demonstrations 2. Expectation guidance	✓ 1. User videos on Sound Word Solutions' Web site 2. Rechargeable (USB)	● User manual only
Web site	www.etymotic.com/consumer/personal-sound-amplifiers/bean-qa.html	www.soundworldsolutions.com/store/personal-sound-amplifiers-psa/cs50	www.tweakhearing.com/shop/tweak-focus-personal-sound-amplification-product/	www.soundhawk.com/product	www.songbirdhearing.com/products/songbird-ultra-20.770091
Price	\$349/each; \$599/pair	\$349	\$224.99	\$349.99	\$395/each; \$745/pair

✓ Fully available
 ● Partially available
 ✗ No special feature
 The Frequency Output was tested using simulated real-ear measures consistent with best practice hearing aid verification procedures. The Signal-to-Noise Ratio (SNR) ratings were based on expected improvement in SNR given the processing approach. For Listening Comfort, a true noise reduction algorithm is best; however, "Low internal noise" as measured via electroacoustic analyses indicates no unpleasant circuit noise and so was included as a comfort feature.

Table 2 Key Communication Strategies

Strategy	Rationale
Speak face-to-face	When the speaker's face is turned toward the listener, there is improved signal-to-noise ratio, and the listener uses facial cues to fill in the gaps that he/she may not have heard.
Reduce background noise	The ability to understand speech in the presence of background noise or distractors (eg, television or restaurant noise) declines as a function of age, even for older adults without hearing loss.
Speak slower, instead of louder	When someone speaks loudly or shouts, it actually distorts the speech, often making it more difficult to understand. Also, shouting can make both the speaker and the listener more stressed.
State the topic	By making the topic of conversation clear at the beginning, the listener can more effectively use context cues to fill in the gaps.
Rephrase the statement	Repeating oneself becomes frustrating for the speaker and the listener. When the question or statement is rephrased, the listener has more context cues to fill in the gaps. In addition, some words are actually easier to hear, depending on the person's hearing loss and the frequencies of the sounds in the word.

speech or background noise (eg, a steady fan sound) and reduce how much gain is applied to the background noise. Such algorithms can come at the expense of improving audibility of the speech sounds at times, but they substantially improve comfort for the listener. This is an expected feature of a hearing aid that is becoming more common among self-fit hearing devices (Table 1).

CONSIDERATIONS FOR GERIATRIC PATIENTS

Addressing hearing loss in the older adult requires a broader outlook into the needs of the individual than simply providing amplification. To address hearing loss, one must learn to use a new technology, incorporate use and maintenance of the device into daily routine, and importantly, change one's communication behaviors; all of which come with unique challenges for older adults. This section addresses some aspects of managing hearing loss and using technology that influence the successful treatment of hearing loss for an older adult.

While some "do-it-yourself" hearing device users may be able to incorporate new technology into their daily routine, many users may need additional support to develop the necessary self-efficacy to manage the new technology. Self-efficacy pertains to one's *perceived ability* to succeed in certain situations,²³ and enhancing self-efficacy is an important factor associated with successful use of hearing aids.²⁴ Hands-on practice in a supportive environment with the provision of immediate feedback and correction can enhance self-efficacy; such support can be provided by caregivers or loved ones. Importantly, persons with hearing and visual loss report lower self-efficacy in studies of hearing aid uptake and use.²⁵ Presbyopia is almost universal and may contribute to one's perception that hearing aids are difficult to use and maintain due to the small size. In addition, the majority of hearing aid manuals are considered inappropriate for older adults in terms of readability and literacy level.²⁶ Several of the hearing devices reviewed here include DVD or online video tutorials that provide an important alternative to the small-print manuals generally provided (Table 1). In addition

to visual changes, manual dexterity tends to decline with age, making the small earpieces and batteries of traditional hearing aids a particular challenge for many older adults. Some hearing devices incorporate a larger ear piece (similar to many Bluetooth devices) and large, rechargeable batteries that are easier to manipulate than some traditional hearing aid styles and small hearing aid batteries (Table 1).

Beyond the potential physical challenges of new technology, a growing sector of hearing devices includes features that rely on the use of smartphones, either to program and personalize the device or to use the earpiece as a Bluetooth headset. This compatibility increases the functionality and flexibility of hearing devices, however, only 18% of older adults own smartphones.²⁷ While some of the devices require a smartphone in order to use the device, others can be paired with a smartphone via Bluetooth for initial set-up and then used regularly without a smartphone. For example, a child or caregiver may provide his/her smartphone to program the hearing device to the patient's needs, but the patient will not need the smartphone to take advantage of the programmable nature of the hearing device (Table 1).

Another potentially challenging feature of hearing devices to consider, which also applies to hearing aids, is the method by which the amplification device provides warnings and signals (eg, low battery, indicate volume level or setting). Oftentimes, manufacturers sell a universal model that uses beeps and tones to indicate warnings and settings, which older adults with hearing loss may struggle to hear, interpret, and remember. Voiced prompts provide easily interpreted feedback on the device's status. Some hearing devices include this feature and may be of particular assistance to patients with significant hearing loss or cognitive impairment (Table 1).

Beyond hearing devices worn at the ear level, there are other assistive listening devices that can provide particular benefit to older adults with significant manual dexterity limitations or cognitive impairment. One example is the Williams Sound Pocketalker (Williams Sound, Eden Prairie, MN), which provides easy-to-wear headphones, simple volume and tone dials, and a microphone that can be placed

near a speaker. Other useful devices include amplified telephones and devices for the television (eg, TV Ears; TV Ears, Inc., Spring Valley, CA). Although devices such as amplified phones and the Pocketalker do not represent the latest technology, they can be important, affordable, and accessible amplification tools.

As highlighted throughout this review, amplification is the primary tool used to improve communication for people with hearing loss. Nevertheless, amplification does not address all communication challenges that are typical of age-related hearing loss. This important fact differentiates age-related hearing loss from presbyopia and the use of over-the-counter glasses wherein the visual problem is generally due to a refractive error rather than an underlying sensorineural loss in the retina. Education and coaching on the use of communication strategies improves communication regardless of amplification use.²⁸ There are available resources from consumer advocacy groups (eg, www.hearingloss.org) for providing communication strategies to individuals and families in primary care clinics. **Table 2** provides examples and rationales for some of the most commonly used communication strategies.²⁹ These communication strategies should be recommended to patients with hearing difficulties and their communication partners. The person with hearing loss needs to advocate for him-/herself and use these strategies to prevent withdrawing from conversation.

CONCLUSION

Communication fundamentally connects people to life and each other. The importance of hearing should not be downplayed as a function of age. There are many options ranging from communication strategies to direct-to-consumer hearing devices to professionally fitted hearing aids that can improve communication and quality of life for the millions of older adults with age-related hearing loss. With improving access to hearing technologies available via Internet sales, the burgeoning direct-to-consumer hearing device market offers a stepping stone by which people can address hearing loss in small steps and begin using amplification.

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