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# A Contemporary Understanding of Unilateral Hearing Loss for Health-Related Professionals

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**Abstract**

Unilateral hearing loss (UHL), hearing loss in one ear only, has continued to gain interest in recent years as evidence accumulates pointing to the potential negative effects that this type of hearing loss may have on a person's daily life. The debate over appropriate diagnosis, treatment and interventions for UHL continues. A review of current literature of the implications and treatment for UHL is provided and management across the lifespan is discussed.

*Keywords*: unilateral hearing loss, single-sided hearing loss, hearing loss, life care planning

**Background**

Humans have two ears for a reason. Binaural hearing – or hearing with two ears – contributes to a person's ability to hear and understand speech in noise (Rothpletz, Wightman & Kistler, 2012; Welsh, Welsh, Rosen & Dragonette, 2004) and to find the source of speech or sound (i.e., localize sound) (Priwin, Jönsson, Magnusson, Hultcrantz & Granström, 2007; Slattery & Middlebrooks, 1994). Additionally, binaural hearing, or the lack of, is known to contribute to one's overall quality of life (Wie, Pripp, & Tvete, 2010).

Unilateral hearing loss (UHL) occurs when a person has hearing within the normal range in one ear, but hearing loss in the opposite ear. The condition can be congenital or acquired. It can be caused by issues such as malformation of the structure of the ear, injuries to the head or neck, surgical complications (e.g., removal of a tumor or reconstructive surgery), Meniere's disease (Grimes, 2017; Rolfs et. al, 2017; Tharpe, 2007) as well as infections and/or use of ototoxic medications/drugs. The term unilateral hearing loss is sometimes interchanged with single-sided deafness (SSD) or asymmetric hearing loss. Unilateral hearing loss and SSD share the commonality of the hearing loss being in only one ear; however, the term SSD is used only when the opposite ear has profound hearing loss. Unilateral hearing loss is a type of asymmetrical hearing loss and it exists when the hearing sensitivity is different between the two ears. Not all asymmetrical hearing losses are unilateral. Some asymmetrical hearing losses may be bilateral (occurring in both ears).

**Prevalence Data**

Prevalence data for UHL varies among reports and must be pieced together across the lifespan. In order to put UHL data in perspective, it is important to examine the overall prevalence of hearing loss in the general population. The Centers for Disease Control (2010) estimates that two to three babies out of every 1,000 live births will have some detectable level of hearing loss in one or both ears. By the time a child reaches school age, it is estimated that six to seven per 1,000 children will have permanent hearing loss (Bamford et al., 2007; National Institute on Deafness and Other Communication Disorders, 2007). Lin, Niparko & Ferrucci (2011) used data from a nationally representative data set to estimate the overall prevalence of hearing loss in individuals older than 12 years in the United States as being approximately 48.1 million people or 20.3% of the population. This number continues to rise.

In examining prevalence data solely focused on UHL, the Lin et al. (2011) analysis reveals that approximately 18.1 million people in the United States (U.S.) (12 years of age and older) have UHL, or about 7.8% of the U.S. population. In children aged 6 years to 19 years, the prevalence of UHL ranges from 3% to 6% in the U.S. (Ross, Visser, Holstrum, Qin, & Kenneson, 2010). Lastly, in newborns, it is estimated that anywhere from 1 in 1000 infants to 30 in 1000 infants have UHL at birth (0.1 – 3 %) (Gravel, 2005; Prieve et al.,

2000).

**Effects of Unilateral Hearing Loss**

The most significant effects of UHL, across the lifespan, are

a. difficulty with localization (being able to find sound or speech) (Priwin, et al., 2007; Slattery & Middlebrooks, 1994), and
b. difficulty in understanding speech, especially in reverberant and noisy environments (Rothpletz, et al., 2012; Welsh, et al., 2004).

In UHL, both of these complaints or concerns are related to the same issue - the loss of auditory cues that are provided to the brain through binaural hearing (two ears). When hearing is normal in both ears, the ear closest to the sound source receives the signal earlier (timing cue) and at a higher intensity (or loudness cue). The differences in these cues for a sound arriving to two ears are critical for a person in the processing of complex auditory signals such as localization of sound and understanding speech in the presence of background noise or in environments with poor acoustics. A person with a measurable UHL, becomes a monaural, or one ear, listener. The patient then loses access to these timing and loudness cues that exist in the case of binaural hearing. Difficulty in processing these timing and loudness cues both in conversation (e.g., missing speech if the deaf side is facing away from the speaker) and in the environment (e.g., missing sound of vehicle when crossing the street) put a person at risk for hearing-loss related problems such as personal safety as well as reduced well-being and self-confidence (Falvo, 2009; Hough, Donnelly & Baguley, 2009; Newman, Hug, Jacobson, & Sandridge, 1997; Tharpe, 2008; Welsh, Welsh, Rosen, & Dragonette, 2004).

The effects of UHL are more serious for congenital and acquired childhood UHL, including delays in the development of speech and language skills, educational progress and psychosocial development (Bess, Rothpletz, & Dodd-Murphy, 2002; Grimes, 2017). It is estimated that 30-50% of children with UHL have problems learning in school, resulting in children with UHL being 10 times more likely to fail a grade or need special help to keep up in school (Bess, 1982; Bess, Dodd-Murphy, & Parker, 1998). Until the 1980s, it was believed that UHL was inconsequential and that students with UHL could go through school without hearing assistive technology or any extra supports and learn just like any other child (Grimes, 2017; Tharpe, 2007). However, more recent studies have indicated otherwise. Anne, Lieu, & Cohen (2017) report that most recent studies of children with UHL revealed poorer speech and language skills when compared to their typically hearing peers. Verbal intelligence scores (VIQ) have also been found to be lower than the child's performance IQ (PIQ) scores, with severe to profound UHL leading to lower full-scale IQ (FSIQ) scores than children with lesser degrees of UHL (Tharpe, 2008).

Because most rules of social interaction are learned via subtle auditory cues and visual cues, rather than direct teaching, it should not be surprising that approximately 20% of children with UHL will develop behavioral or social issues (Arndt et al., 2016). Tharpe (2008) reported that in children with UHL, only 51.7% were rated by their teachers as performing satisfactorily in school and 20% were identified as exhibiting behavior problems including social withdrawal, inattention, distractibility, lack of cooperation, and aggression. Rolfs et al. (2017) reported that behavior problems and difficulties in students with UHL can be 2.4 times higher than students without hearing difficulty, surmising that the behavioral problems are due to hearing loss and the associated deficits in attention and communication.

Given the potentially significant impact of UHL in both children and adults and the continual developments and improvements of technology that provide auditory access to individuals with UHL, the purpose of this paper is to examine current trends in the published literature regarding the definitions of UHL, discuss treatment options available, and outline recommendations for rehabilitation and life care planning.

**Anatomy & Physiology**

The sense of hearing occurs when a sound wave enters the outer ear, travels down the ear canal and causes the tympanic membrane (i.e., eardrum) to vibrate. On the opposite side of the eardrum from the ear canal is the middle ear space that houses the smallest bones in the body (i.e., malleus, incus, and stapes), known as the ossicles. The vibration of the eardrum travels down the chain of ossicles (i.e., the ossicular chain) where sound is amplified or increased. The last bone in the chain, the stapes, has a footplate that sits in what is called the oval window into the inner ear. As the sound moves medially from the vibration of the eardrum down the ossicular chain, the stapes vibrate the oval window causing the fluid in the inner ear (composed of the cochlea and vestibular system) to be set into motion, thus converting the mechanical signal to a hydraulic signal. Three fluid-filled channels of the cochlea are set in motion by the movement of the oval window. The channels are separated by a thin membrane so that movement from one channel impacts the movement of another channel. The middle channel of the cochlea (also called the organ of Corti) is lined with small hair cells that have nerve fibers which help to send the signal (transmitted from the movement of the fluid to the hair cells) to the auditory nerve. The signal is then transmitted to the auditory cortex in the brain. As fluid moves in the cochlea, the hydraulic signal is converted into an electrical signal at the level of the auditory nerve as the hair cells in the organ of Corti create nerve impulses. This pathway allows for sound to be transmitted to the auditory cortex of the brain located in the temporal lobes on both the right and left sides of the brain (Fucci & Lass, 1999; Seikel, King, & Drumwright, 2000). A breakdown in any part of this process, from the initial acoustic signal to the outer ear to the electrical pulse created in the inner ear that travels to the brain, can cause hearing

loss. Figure 1.1 provides a visual representation of the anatomy involved in hearing. For an individual with UHL, one ear functions normally and the other ear experiences a loss in hearing. This could be due to a structural anomaly, genetic condition, viral infection, or a number of other etiologies as previously discussed.

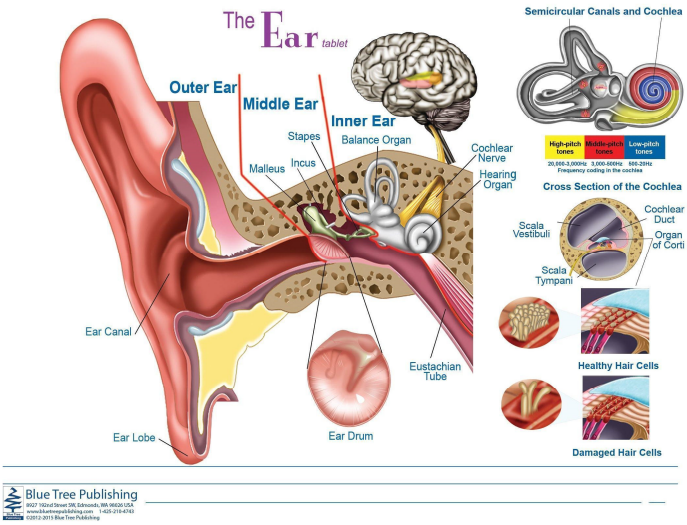


*Figure 1.1 Anatomy of Hearing*. A visual display of the anatomy involved in hearing to the level of the auditory nerve. The auditory cortex is not represented in this figure. Reproduced with permission from Blue Tree Publishing Company.

**Technology Options**

The debate continues as to the appropriate technological treatment for UHL. There was a time when no hearing technology was recommended; however, this is no longer the case. It is important that providers across health-related fields recognize the impact UHL can have on an individual, be prepared to refer appropriately, and be familiar with current technology options available.

Amplification options for UHL fall into several broad categories. Each category approaches intervention from a different vantage point.

1. Making sound louder to poorer hearing ear: traditional hearing aid
2. Electrically stimulating the auditory nerve of the poorer hearing ear directly: cochlear implant
3. Routing sound from the poorer hearing ear side of the body to the normal hearing ear: Contra-lateral Routing of Sound (CROS) hearing aids or a bone conduction device
4. Improving the signal to noise ratio at the better hearing ear: remote microphone technology and/or group amplification distributions systems

The use of a traditional hearing aid or a cochlear implant with UHL are aimed at utilizing both auditory pathways (right and left) whereas the other amplification options listed here will only use the auditory pathway of the better hearing ear.

**Traditional Hearing Aids**

A traditional type of hearing aid may be used with certain UHLs. Traditional hearing aids are typically hearing aids that either sit behind the ear or fit in the ear canal. Hearing aid technology utilizes a microphone which picks up sound which is then amplified by a microprocessor in the hearing aid. Today's signal processing strategies in appropriately fit hearing aids allow the user to have auditory access to speech without it being uncomfortable because it is too loud. Additionally, hearing aids feature technology that increases speech intelligibility and comfort, by reducing feedback and noise as well as using different microphone arrays that allow the wearer to better hear the person in front of them (directional microphone). The amount (degree) of hearing loss, along with the configuration and type of UHL will be used by the audiologist or hearing health care provider to determine the appropriateness of the use of a traditional hearing aid.

There is little published research evidence that supports the effectiveness of the use of a traditional hearing aid in UHL, either for adults or for children. One supposed benefit of the use of a traditional hearing aid in UHL is that it provides stimulation to the auditory pathway of the affected ear. Also, a traditional hearing aid in the ear with hearing loss may provide useful cues related to binaural hearing which improves localization and the ability to hear speech in background noise. However, it is important to note that individuals with moderate to profound UHL may experience limited benefit from a traditional hearing aid due to the severity of the hearing loss and poor speech perception in the ear with hearing loss, even when the hearing aid is being used (Dillon et al., 2017).

In the pediatric population, there have been a few reported studies related to the perceived benefit of the use of a traditional hearing as reported by the child and the parent. In a relatively small sample of eight children with UHL, Briggs, Davidson, and Lieu (2011) did not find a significant improvement in speech perception with the use of a traditional hearing aid. However, the children (and parents) in the study did report significant subjective benefits when using a traditional hearing aid in the poorer hearing ear, one of which included increased quality of life.

One specific case example of the use of a traditional hearing aid in UHL is a 22-year-old male (whom we will call John) who has normal hearing in his right ear with a moderate, sensorineural (i.e., permanent) hearing loss in his left ear. This hearing loss was diagnosed when he was 4 years old. At that time, the clinic-based audiologist recommended to his family that he try a traditional hearing aid in his left ear (NOTE: There are several amplification options that would address this hearing loss. Most likely the audiologist recommended a traditional hearing aid due to the age of the patient and the degree/configuration of the hearing loss). The

family completed a trial period with a hearing aid and reported that John appeared to be able to understand speech, particularly when more than one other person was involved. Additionally, John was able to find sound (localize) more easily when he wore the hearing aid in his left ear, which contributed to his overall well-being because his family felt that he was safer by being able to identify where sound was coming from at any given time. John has continued to use a hearing aid in his left ear and has actually had four (4) different hearing aids from his initial diagnosis to the present. These different hearing aids have represented upgrades in technology across time that have included better signal processing (which has provided him with increased ability to understand speech) as well as increased connectivity with other devices (e.g., Bluetooth to cell phone).

The cost of a traditional hearing aid varies widely (cost range: $500 - $3,000 per hearing aid). The variability in cost has many explanations – here are a few of the reasons for the differences in costs:

- Features of a given hearing aid: If a person opts for more signal processing features, the hearing aid will often cost more
- Bundling or unbundling of product and service: The hearing aid care provider (e.g., audiologist) may include the fitting fee and follow-up visits in the initial cost of the hearing aid and thus, the cost may seem higher. Proper fitting and follow-up are needed in order for individuals to get the most benefit from amplification devices

Some insurances cover the cost of a traditional hearing aid - but some do not. Individuals should check their personal policies and supplemental plans for details.

**Cochlear Implant**

A cochlear implant (CI) is a medical device that provides direct electrical stimulation to nerve fibers in the inner ear which are linked to the auditory nerve. Cochlear implantation requires surgery under general anesthesia to place the internal part of the implant which includes an electrode array placed in the cochlea (inner ear) as well as a magnet that is embedded in the mastoid bone behind the ear. This magnet will eventually help to hold the external device to the head. Typically, two to three weeks after the surgery, once the surgical site has healed, the external device will be placed and programmed. There are three manufacturers of cochlear implants and each of their websites has in-depth information about how a cochlear implant works (Advanced Bionics, https://www.advancedbionics.com; Cochlear, https://www.cochlear.com/us/home; MED-EL, http://www.medel.com/us/)

In the case of UHL, cochlear implants have been used in cases of profound UHL (also referred to as SSD). However, at the current time, the use of a CI in UHL is not an approved indication by the Food and Drug Administration (FDA) in the United States. There has been a lot of interest in its use with UHL because of the potential for the restoration of the sense of hearing in the poorer hearing ear and thus, the potential for binaural hearing. The data that is available on the use of CI for UHL has been obtained from the use of these devices outside of the U.S. or from off-label implantation in the U.S. (Gifford, 2017). There are five clinical trials going on in the U.S. to examine the efficacy of a CI in SSD as of May 2018.

The evidence collected and reported thus far for the use of a CI with UHL is promising. Overall, studies have reported improved localization and ability to hear speech in the presence of competing noise. Additionally, participants have reported subjective benefit in being able to hear in daily life activities (Firstz, Holden, Reeder, Waltzman, & Arndt, 2012; Friedmann et al., 2016; Mertens, Punte, De Bodt, & Van de Heyning, 2015). More data are needed to convince the FDA and other stakeholders to approve CI for standard use with UHL.

Suzanne is a 45-year-old woman who experienced sudden onset of profound UHL in her right ear one year ago. The exact cause of the sudden hearing loss is unknown but Suzanne's otolaryngologist has predicted that it was caused by a viral infection. Suzanne is a business analyst for a large corporation and often participates in group meetings. After the onset of her hearing loss, she began to experience great difficulty in hearing others in these meetings, especially if there was any type of competing noise (e.g., others having side-bar conversations, heating or air conditioner noise). Suzanne received a cochlear implant in her right ear six months after the onset of her UHL. After the activation of her device and several weeks of auditory (aural) rehabilitation, Suzanne's ability to localize sound and to understand speech in noise was significantly improved. Although she realizes that her ability to hear and understand in group meetings is still impacted, she is much more confident that she will be able to continue her work after receiving her cochlear implant.

The cost for cochlear implantation ranges anywhere from $30,000 to $60,000 (single side). This includes the cost of pre-implant evaluations, surgical costs (physician and hospital costs), as well as the device itself and post-implantation activation and follow-up. In most cases, the internal portion of the device should not have to be replaced, but the external device may need to be upgraded over time (at a cost of $8,000-$10,000).

In general, most private insurance plans and public assistance programs will cover the cost of a cochlear implant in the case of bilateral hearing loss. However, because a CI is not currently indicated for use with UHL by the FDA, it is very possible that the costs will not be covered by insurance or other payment sources. Individuals should check their personal policies and supplemental plans for details.

**Contra-lateral Routing of Sound (CROS) Hearing Aids**

Another option for the treatment of UHL is the use of CROS (**C**ontralateral **R**outing of **S**ignals) hearing aids. With this option, the patient wears a hearing instrument on each

ear. The instrument on the poorer ear is merely a microphone that is picking up sound/speech on that side of the body and transferring (or routing) it to the instrument on the ear that has normal hearing via a wireless signal. Neither instrument is amplifying the sound/speech but is simply "sharing" the sound/speech occurring on the side of the body with the poor hearing ear to the auditory system via the normal hearing ear.

Early versions of the CROS hearing aid did not provide the outcome that was expected initially. Acceptance among users was low (Harford & Dobbs, 1966), localization did not improve (Markides, 1979) and the understanding of speech in background noise was impaired when the speech was presented on the normal hearing ear side (i.e., the noise was being picked up on the side of the poorer hearing ear and routed to the ear with normal hearing) (Lotterman & Kasten, 1971). However, because of improvements in signal processing and wireless transmission of the sound from one side to the other, modern versions of the CROS hearing aid have been shown to improve speech in noise abilities in certain listening situations (i.e., speech poorer ear/noise better ear, speech front/noise front, and speech front/noise back) (Snapp, Hoffer, Liu & Rajguru, 2017). An individual who was unsuccessful with this type of amplification in the past might find it useful to try the more updated version of the CROS system.

Jim has had UHL for as long as he can remember. He recalls trying a traditional hearing aid as a child but he did not wear it consistently and eventually his parents and audiologist decided to discontinue the use of the hearing aid. As a young working professional, Jim wanted to try amplification to see if he could improve his ability to hear speech in the presence of competing noise. His audiologist recommended a wireless CROS hearing aid system and Jim has been using it for the last two years. Specifically, Jim wears the system at work (always) and in social situations when he knows he will need to be able to hear speech in noise and when there will be multiple talkers. He reports that he can tell a significant improvement in his ability to hear speech in meetings and at social functions when there are several conversation partners. He also notes that he feels less tired when he uses the system than when he does not use it.

The cost of a CROS hearing aid system will be similar to that of a traditional hearing aid with a range of features. The same will be true of insurance coverage for CROS hearing aids - some insurance plans may cover the cost, but many will not. Individuals should check their personal policies and supplemental plans for details.

**Bone Anchored Implants**

The use of bone conduction is not new in the world of amplification. Bone conduction hearing aids have been around for many years and were used most frequently in cases where traditional hearing aids could not be fit (e.g., bilateral anatomical anomalies such as atresia where there is no opening to the ear canal). However, the use of bone conduction of sound for UHL is relatively new, specifically, the advent of bone anchored implants (BAI) to treat the SSD version of UHL. A BAI consists of a titanium implant anchored in the temporal bone (behind the ear) and a sound processor that snaps onto the implant (via an abutment). Sound on the side of the poorer hearing ear is picked by the processor and transferred by bone vibration (via the implant) to the inner ear on the opposite side where there is normal hearing sensitivity.

Bone anchored implants can be worn on a softband with the sound processor typically placed behind the poorer hearing ear (in children up to 5 years of age or in cases where families/individuals choose to pursue surgical options). Most adults choose to have BAI surgical placed in the mastoid. The implant has to integrate itself in the bone (osseointergration) which typically takes 3-6 months. Once the implant is integrated, the sound processor portion of the BAI can be snapped on and no headband is needed to wear the device. The latest development with BAI devices is the use of a very strong magnet – one under the skin (around the mastoid process) coupled with one in the external device itself.

Current outcomes data for BAIs are similar to the newer CROS hearing aid systems - improvement of speech understanding in noise in certain listening situations (i.e., speech poorer ear/noise better ear, speech front/noise front, and speech front/noise back) with little improvement in localization ability (Finbow, et al., 2015; Saroul et al., 2013; Snapp, Hoffer, Liu & Rajguru, 2017; Snapp, Holt, Liu & Rajguru, 2016).

Bonnie, a 7-year-old in the second grade, was born with severe UHL. Initially her family tried a traditional hearing aid when she was a baby. However, it was difficult to keep on her and they did not see any changes or benefit when she wore it. She tried a BAI on a softband and immediately her family saw a difference in how she responded to speech and sound in general. When she was 6-years-old, her family decided to proceed with the surgical implantation of the titanium portion of the implant so that she could use the sound processor without the softband. Bonnie is doing well in school and if you cannot see the sound processor behind her ear, you would not realize that she has UHL.

Estimates regarding the cost for a bone anchored implant are between $5,000 and $10,000. This should include the surgical costs (physician and hospital/surgical center) as well as the device. The external sound processor will need to be replaced every 3-7 years and should be similar in cost to a traditional hearing aid.

**Remote Microphone Technology**

Typically used in school settings, these devices utilize a wireless microphone that the teacher (or speaker) wears while the student wears some type of receiver that receives the

signal transmitted from the wireless microphone on the teacher/speaker. There are different ways to transmit the sound from the microphone to the student (i.e., frequency modulation or digital modulation). There has been an increase in the number of adults utilizing remote microphone technology over the last few years.

Traditional, standalone remote microphone systems will have a receiver that is usually worn in the listener's better hearing ear while the speaker (or desired sound source) wears the transmitter/microphone. Receiver setups include:

1. a device that looks like a hearing aid worn on the better hearing ear
2. a receiver that is worn around the neck and is connected to an earbud(s) or headphones that the listener wears
3. in some cases of UHL where a traditional hearing aid is used, the receiver may be attached to the hearing aid.

The rationale for remote microphone technology is to move the microphone, which picks up the sound closer to the sound source and transmits it wirelessly to the listener. This increases the signal to noise ratio with the desired outcome to be that the sound source, which the listener wants to hear, is more prominent than the background noise.

Evidence to support the need for remote microphone technology with UHL is mostly limited to studies in children in classroom settings. Increasing the signal to noise ratio provides an advantage for children with UHL in academic settings especially when listening to speech in the presence of background noise (Kenworthy, Klee, & Tharpe, 1990; Tharpe, Ricketts & Sladen, 2004; Updike, 1994). Although there is limited data indicating that adults with UHL gain significant benefit from the use of a remote microphone system, it is an option that may appeal to some adults with UHL.

Henry is a professor at a small liberal arts college where he teaches English literature. He has a moderate UHL in his right ear and is not interested in wearing a traditional hearing aid in his poorer hearing ear. However, he sometimes has difficulty hearing students when he is teaching in a lecture hall. He recently was fit with a remote microphone system. He wears a small receiver device in his left ear (better hearing ear). He passes a remote microphone around the classroom and has requested that the students use this microphone (transmitter) when they want to ask a question or participate in the discussion. Although it does slow the process of conversation down, Henry reports that he has seen a significant improvement in his ability to understand all students when they are talking regardless of where in the classroom they are seated.

These systems may be less costly than some of the other options, while providing individuals with an improvement in their ability to hear speech, especially when background noise is present. Top of the line remote microphone systems will cost $2,000-$3,000 for one receiver and a transmitter. Less expensive options may be available but the individual should always ask for the an opportunity to try a device before purchasing. Typically, this type of amplification is not covered by insurance policies or public assistance. Instead, the user will be responsible for the purchase. In some cases, children may be provided these devices by a public school system.

**Group Amplification Distribution Systems**

These types of systems may be referred to as sound-field systems or surround sound systems. Regardless of what they are called, they are similar to remote microphone systems in that they employ the use of a transmitter/microphone placed on or by the desired sound source (i.e., teacher or presenter). The difference is that sound or speech is projected via a speaker system in the same way that a public address (PA) system works. The premise is to increase the signal (preferred sound) to noise (everything else) ratio so that the desired sound/speech is heard.

These types of systems have been used for UHL more in the pediatric population in academic settings. Although there is limited published research data on the whether or not the use of a sound field system specifically improves academic outcomes for children with UHL, there is data that suggests that all children benefit from the improved signal to noise ratio that these systems provide (see Henney, 2007 and Rosenberg et al., 1999). In a practical sense, adults, regardless of hearing status, find that the use of a PA system in large spaces is preferable to no general sound amplification at all.

Sandra recently began attending a new church in her local community. She has UHL in her left ear and does not use any type of personal amplification. She finds that she is able to function in her daily life without a hearing aid. However, when she attends church she is dependent on the pastor to use the PA system. One Sunday the system was not functioning properly and Sandra struggled to hear the sermon despite sitting close to the pulpit. She spoke to the pastor after the service to share with him that she depends on the sound system. He assured her that it would be in working order by the next scheduled service.

The cost of sound amplification distribution systems varies widely ($700-$10,000) depending on many factors including the size of the space that it will be used in, the number of sound speakers needed, as well as potential installation costs.

**Assisting with amplification and hearing assistive technology**

Life care planners may assist individuals who have UHL hearing loss by referring them to appropriate hearing healthcare providers (i.e., audiologists). Not all hearing healthcare providers are equipped to offer individuals all of the amplification options discussed here. Encourage individuals to seek out providers who can discuss the options that are of interest to them and to request a referral to specialized providers when needed. Typically, CIs and BAIs

are available at facilities associated with medical practice (ENT) and/or hospitals.

Life care planners can assist individuals who have amplification by asking if the devices are functioning properly. If a life care planner notes that an individual's response patterns are inconsistent, discussion of return to the audiological professional is certainly something that the life care planner can do. Care and maintenance are needed for amplification devices including fresh batteries, cleaning tools and drying products (i.e., to remove moisture from the device) and should be included in the life care plan for individuals needing assistive technology. Annual visits to the hearing healthcare provider are the standard of care and usually recommended for all amplification users.

If an individual expresses issues with his or her amplification device, it would always be appropriate for the life care planner to encourage the individual to return to their hearing healthcare provider as soon as possible. Any time an individual indicates a change in hearing ability, life care planners should suggest an updated hearing evaluation - even for individuals who may be unaware of amplification options. Changes in hearing sensitivity sometimes are indicators of other medical issues.

**Management across the Lifespan & Life Care Plan Implications**

A range of rehabilitation options exist to improve listening ability, but none can restore true binaural hearing (hearing in both ears). For an individual with UHL, a critical first step is gaining good access to sound is by a thorough evaluation with an audiologist who has experience in working with individuals with UHL. After a decision regarding access to sound (i.e., the use of amplification) is made by the individual and the managing audiologist, the next issue to consider is to what extent do the speech, language and functional auditory skills of the individual need to be assessed and potential intervention provided. Referral to a speech-language pathologist, preferably one who has experience in working with children or adults who have hearing loss, is recommended.

The frequency and length of audiological evaluations for the individual with UHL depends on several factors including age and type of amplification device selected. Children will need to be seen more often for follow-up visits than adults. Children receiving hearing devices typically need to see the managing audiologist every six months through childhood. Adults with hearing devices, by contrast, typically undergo audiological evaluations yearly throughout life expectancy. For individuals with UHL who receive a CI, visits to the audiologist will be more frequent during the candidacy phase as well as during the activation phase.

For UHL, in addition to updated hearing tests and hearing device checks, speech language pathology evaluations and therapy sessions may be recommended. Children should have a baseline speech-language and auditory skill assessment when the UHL is identified. When UHL is identified during adulthood, referral to a speech-language pathologist is appropriate if the individual is concerned about their communication and/or listening skills. As is the case for audiological evaluations, speech, language and auditory skill assessment and treatment for individuals who receive a CI will be more frequent and is a requirement for many centers that provide cochlear implantation. To address psychosocial issues, additional professional assistance may be required (Hough, Donnelly & Baguley, 2009). Consideration should be given to the need for treatment of psychological symptoms as children with hearing loss report lower levels of energy and attention and higher levels of stress and exhaustion than children with typical hearing. This is attributed to the fact that they are required to exert more energy when listening in a classroom setting than their peers with unaffected hearing (Arndt et. al., 2016; Grimes, 2017; Tharpe, 2008). Fatigue due to hearing loss is not unique to children; therefore, this is a topic to be discussed by other health professions who interact with individuals with hearing loss including but not limited to vocational rehabilitation counselors. Auditory fatigue has the potential to impact an individual's job satisfaction and satisfactoriness as well.

Environmental accommodations should also be considered for the individual with UHL. Within a preschool setting, something as simple as placing carpet or rugs in the classroom can help improve the signal-to-noise ratio in the room and decrease reverberation. Within the primary and secondary school setting, accommodations including preferential seating and the use of a classroom amplification distribution system, can improve the classroom experience (Tharpe, 2008). As classrooms have become increasingly noisy (e.g., students working collaboratively in groups) it is important that the environment be set up in a way that the student with UHL has ample access to speech and thus has an opportunity to benefit from conversations in the classroom. The Job Accommodation Network (JAN) recommends the following work-environment accommodations that might be useful for people with hearing loss: use written notes, use computer technology, (i.e., e-mail and instant messaging), provide an assistive listening device or speech recognition software, address environmental factors, (i.e., background noise, lighting, and positioning), and place mirrors strategically around the work area to help alert the employee to the presence of customers (JAN, 2013). These same accommodations can be used within a school setting for students with UHL. Counseling should be extended to classroom teachers, co-workers and employers who can be coached about communication (i.e., methods to reduce background noise, strategies to improve signal-to-noise ratio, and communication repair strategies) which increases the likelihood of the individual with UHL receives all intended information within an educational and/or working environment.

**Conclusions**

While most life care planners originate from medically-related fields, most are not speech-language pathologists or audiologists. When referred a case involving unilateral hearing loss, most life care planners should consult with individuals skilled in this area, as recommended by life care planning standards of practice (International Association of Rehabilitation Professionals, 2015). As life care planning literature require the life care planner to be familiar with relevant, related research, this article provides important information to the life care planner regarding the interventions and devices currently considered for treatment of unilateral hearing loss. Understanding the differences among devices for UHL, as well as the costs and treatment protocols involved with each, the life care planner will be armed with information necessary to educate all involved to best evaluate an individual's future life care needs.

*Editor's Note: Costs and replacement schedules noted in this manuscript are for educational purposes. As each life care plan is individualized, life care planners are encouraged to conduct independent research about costs and replacement schedules for items contained in an evaluee's life care plan.*

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