# Hearing Loss

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Introduction

This section contains information about some of the medical aspects of hearing and hearing loss and information about audiology. It explains the following:

- sound
- how the ear works
- audiology and the audiogram
- the types and degrees of hearing loss
- the effects of hearing loss
- how to meet the needs of students with hearing loss

Questions about a student’s hearing loss can be answered by his or her audiologist. A speech-language pathologist and/or teacher of the Deaf and/or hard of hearing will also be able to provide more information.
Hearing

Sound

Sound is an invisible vibration that begins from movement. Sound is measured in both intensity (loudness) and frequency (pitch).

Intensity is measured in decibels (dB). Frequency is measured in hertz (Hz). Most sounds are made up of a range of different frequencies.

An example of a high frequency, or high-pitched sound, is the noise made by a whistle. An example of a low frequency, or low-pitched sound, is the noise made by a big drum.

Speech is usually a mix of high, middle, and low pitched sounds. Consonant sounds, like /p/, /k/, and /s/, tend to be higher in frequency than some vowel sounds, like /aa/ as in part.

The Ear

The ear has two main functions. It receives sound and converts it into signals that the brain can understand. It also helps us to balance. The two functions are closely connected.

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The ear is divided into three main sections:

- the outer ear
- the middle ear
- the inner ear

Sound passes through all three sections of the ear before it goes to the brain. The brain interprets the sound and tells us what we are hearing. It tells us if we are hearing music, noise, a voice, a car horn, a dog, or other sounds.

The Outer Ear

Sound goes into the outer ear. The part of the outer ear that we can see is called the pinna.

The outer ear picks up sound waves and directs the sound down the ear canal to the eardrum.

The eardrum (tympanic membrane) is a thin membrane stretched over the end of the ear canal that separates the outer ear and the middle ear. When sound hits the eardrum, it begins to vibrate much like the membrane of a drum when it is struck with a drumstick.

The Middle Ear

The middle ear contains the three smallest bones in the body, each about the size of a grain of rice. Together these bones are called the ossicles. Individually, they are called the malleus (hammer), the incus (anvil), and the stapes (stirrup).

This chain of bones is attached to the eardrum on one end and the inner ear on the other end. The ossicles form a lever mechanism that conducts sounds from the eardrum to the inner ear.

The Inner Ear

The inner ear is housed in the bone of the skull. This part of the ear contains the semicircular canals, the cochlea, and the auditory (hearing) nerve.

The semicircular canals are fluid-filled bony structures that are responsible for balance. When you feel dizzy on a fair ride, this is because the fluid in the semicircular canals has been disturbed.
The cochlea is shaped like a snail and is filled with fluid. It is lined with thousands of tiny nerve endings called hair cells. These hair cells are tuned somewhat like the keys on a piano. Some of the hair cells respond to low-pitched sounds, and some respond to high-pitched sounds.

These hair cells are connected to the auditory nerve that connects the cochlea to the brain.

Audiology

Audiology is the medical term for the study and measurement of hearing and hearing loss.

An audiologist is a professional who is qualified to assess hearing loss and to recommend and fit amplification systems (e.g., hearing aids, FM systems, cochlear implants).

An annual hearing assessment is recommended for students who are D/HH because not all hearing losses are stable.

The Audiogram

The audiogram is a graph that represents a person’s responses to sound. It is used to document the softest sound a person can detect at a variety of different frequencies (pitches).

Frequency

The frequency or pitch of sound is shown by the numbers across the top of the audiogram. Low pitches are on the left-hand side of the graph and high pitches are on the right, somewhat like the keys of a piano, which range from low pitches on one end of the keyboard to high pitches on the other end. The whistle of a bird usually has a high pitch; the growl of a dog has a low pitch.

The frequencies included on an audiogram are chosen because they are important for understanding speech.

Different speech sounds have different pitches, so it is important to know how well a person hears across the frequency range. A good example of different frequencies is the word moose. The /m/ sound is a low-frequency sound, the /oo/ sound is a middle-frequency sound, and the /s/ sound is a high-frequency sound. In order to hear the word completely, a person must have appropriate levels of hearing at low, middle, and high frequencies.
Intensity

The intensity or loudness of sound is shown by the numbers down the side of the audiogram. The small numbers at the top are soft sounds (-10, 0, 10 decibels), and the large numbers at the bottom are loud sounds (90, 100, 110 decibels).

With a complete audiogram, an audiologist can determine the type, degree, and configuration (or shape) of the hearing loss.

The figure on the next page, “Frequency Spectrum of Familiar Sounds,” shows the pitch and loudness of several environmental sounds as well as typical speech sounds. The shape these speech sounds make on this audiogram is commonly called the *speech banana*. The speech banana represents the area of pitch and loudness in which the majority of speech sounds will occur when a person is talking in a normal conversational voice.
**Figure 3**

**Frequency Spectrum of Familiar Sounds**

**Frequency (Pitch) In Cycles Per Second (Hz)**

0 10 20 30 40 50 60 70 80 90 100 110 120

**Hearing Level (Intensity) in Decibels (db)**

0 10 20 30 40 50 60 70 80 90 100 110 120

- **Water Dripping**
- **Talking**
- **Vacuuming**
- **Whispering**
- **Watch**
- **Rustling Leaves**
- **Airplane**
- **Helicopter**
- **Gun Shot**
- **Fire Cracker**
- **Whistling**
- **Dog Barking**
- **Crying**
- **Chain Saw**
- **Motorcycle**
- **Lawn Mower**
- **Truck**
- **Band**
- **Telephone**
- **Piano**
- **Talking**
- **Crying**
- **Fire Cracker**
- **Gun Shot**
- **Helicopter**
- **Motorcycle**

Hearing Loss

Types of Hearing Loss

Conductive Hearing Loss

A conductive hearing loss occurs when one or more of the structures of the outer or middle ear are not working properly. For example, conductive hearing loss may be caused by the following conditions:

- wax buildup in the ear canal
- a hole in the eardrum
- fluid in the middle ear
- problems with the bones of the middle ear

Having a conductive hearing loss is like wearing earplugs: you only hear loud sounds. Most types of conductive hearing loss can be medically corrected.

Otitis Media

Otitis media is a medical term that refers to middle ear infections or inflammation of the middle ear. Fluid in the middle ear is usually, but not always, found with this condition. This fluid may be watery or like mucus, and may or may not be associated with infection.

Otitis media is very common in children, especially young children, and is the most common cause of conductive hearing loss.

The symptoms of otitis media may include the following:

- fever
- ear pulling
- irritability
- inattentiveness
- earaches
- difficulty hearing in one or both ears

Frequent otitis media is cause for concern because of the long-term effects on a person’s ability to listen, process sounds, communicate, and socialize.
Some individuals who have permanent, sensorineural hearing loss (see below) also get otitis media, resulting in additional loss of hearing sensitivity. It is advisable to check young children’s hearing after they have been treated for otitis media.

**Sensorineural Hearing Loss**

A sensorineural hearing loss may result from problems in the following:

- the cochlea
- the auditory nerve
- the hearing centres of the brain

Damage to the hair cells in the cochlea is the most common reason for sensorineural hearing loss. If damaged, the hair cells cannot detect sounds.

Most types of sensorineural hearing loss are permanent and cannot be corrected by surgery or medication.

**Mixed Hearing Loss**

A hearing loss is classified as mixed when both conductive and sensorineural hearing loss are present. For example, someone with a permanent sensorineural hearing loss with a middle ear infection may have additional hearing loss (called “conductive overlay”). After the ear infection clears, and the conductive overlay disappears, the person would be said to have only a sensorineural hearing loss.

**Unilateral Hearing Loss**

If only one ear is affected with a hearing loss, it is referred to as a unilateral hearing loss.

A review of the literature indicates that some students with unilateral hearing loss may be at risk for speech and language delays and/or academic challenges. It is not known at precisely what age the unilateral hearing loss has an impact. While some students will never exhibit an effect from the unilateral hearing loss, others may experience some challenges.

**Bilateral Hearing Loss**

When both ears are affected, it is known as bilateral hearing loss.
Progressive Hearing Loss

A progressive hearing loss is one where, over time, the hearing becomes progressively worse in one or both ears. Some individuals have risk factors for late onset or progressive hearing loss (e.g., prolonged mechanical ventilation at birth, congenital diaphragmatic hernias, large vestibular aqueducts, certain syndromes).

An annual hearing assessment is recommended for students who are D/HH because not all hearing losses are stable. An annual review helps the school team detect changes in hearing acuity and adjust hearing aids as needed.

Degree of Hearing Loss

The level of a person’s hearing loss can be described in two ways:

- as a decibel (dB) hearing level
- as mild, moderate, severe, or profound hearing loss

Hearing loss is not described as a percentage (e.g., 60 percent Deaf).

The table below shows the terms used to describe levels and the decibel levels that they refer to:

<table>
<thead>
<tr>
<th>Degree of Hearing Loss</th>
<th>Hearing Level in dB (Loudness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Hearing Sensitivity</td>
<td>0–15 dB</td>
</tr>
<tr>
<td>Minimal or Slight</td>
<td>16–25 dB</td>
</tr>
<tr>
<td>Mild</td>
<td>26–40 dB</td>
</tr>
<tr>
<td>Moderate</td>
<td>41–55 dB</td>
</tr>
<tr>
<td>Moderate Severe</td>
<td>56–70 dB</td>
</tr>
<tr>
<td>Severe</td>
<td>71–90 dB</td>
</tr>
<tr>
<td>Profound</td>
<td>91 dB or greater</td>
</tr>
</tbody>
</table>

Most individuals with a hearing loss will have some amount of residual hearing. The audiologist, SLP, or TD/HH will be able to give more information about a person’s degree of hearing loss and can explain the sounds that the person may hear and the sounds that the person may not hear.
Deaf, Hard of Hearing, and Deafened

Students who have a hearing loss are referred to as *hard of hearing* or *Deaf* according to their communication skills and cultural affiliation. Generally, students who use American Sign Language and who have identified culturally with members of the Deaf community are considered *Deaf*. (The word is capitalized to indicate a distinct cultural group similar to the capitalization of English, Spanish, or Hebrew.) Students who have a hearing loss but do not have a cultural affiliation with the Deaf community are generally referred to as students who are *hard of hearing*.

Individuals who had hearing and have subsequently lost their hearing, through illness or accident, are referred to as *deafened*. These individuals choose either Deaf or hard of hearing support organizations, based on the degree of their acquired hearing loss.

**Effects of Hearing Loss on Speech and Language WITHOUT Intervention**

Students with **minimal or slight hearing loss** or **unilateral hearing loss** may

- miss some consonants
- experience mild difficulty with auditory language learning
- experience difficulty listening at a distance or in noisy situations

Students with **mild hearing loss** may

- miss quiet speech sounds
- experience difficulty with auditory learning
- experience speech/language delays
- appear to be inattentive

Students with **moderate hearing loss** may

- hear almost no speech sounds at normal levels
- make speech sound errors
- experience language delays
- experience learning difficulties related to language delays
- appear to be inattentive
- need to be less than two metres away from speaker for best listening distance

Throughout this document, the inclusive term *Deaf and/or hard of hearing* or *D/HH* is used. See page 27 of the Identity section for further discussion of terms commonly used in the Deaf community.
Students with **severe hearing loss** may

- hear no speech sounds at normal levels
- speak, but their speech may be difficult to understand
- experience language delays
- experience learning difficulties related to language delays
- appear to be inattentive to verbal communication (may not realize that speaker is speaking)

Students with **profound hearing loss** may

- hear no speech or other sounds
- experience extreme difficulty understanding speech
- produce little or no verbal language
- experience learning difficulties related to language delays
- learn by visual cues or American Sign Language
- appear to be inattentive to verbal communication (may not realize that speaker is speaking)

**Amplification**

Amplification devices such as hearing aids, cochlear implants, and FM systems help to meet the needs of students with hearing loss. The goal of all hearing technology is to enhance the reception of speech.

When amplification has been recommended, consistent use is important.

The technology for a student is chosen, based on individual needs and school team observations, by the audiologist in consultation with the parents. Factors including the type of hearing loss, the degree of hearing loss, and the size and shape of the ears are considered in the decision-making process.

Information about the use and care of hearing aids and FM systems should be provided to the student’s support team. As technology changes, ongoing information sharing is needed to support each student. For example, if a student gets new hearing aids, the FM system may require an upgrade.
Hearing technology should be checked daily, as young students often cannot report malfunctions in their amplification. Management of amplification is the student's responsibility, although support from the school team may be required in Early Years. See page 20 for information on listening checks.

Hearing Aids

Hearing aids are electronic devices that amplify sound. Speech and background noise are amplified by a hearing aid.

Hearing aids work best in a quiet listening situation where the distance between the person speaking and the student is six feet or less. As distance and background noise increase, the benefit provided by a hearing aid is greatly decreased.

It is important to keep in mind that hearing aids do not restore normal hearing. They amplify all sounds. They need to be kept in good working condition and worn consistently. A daily listening check is needed to ensure that hearing aids are working properly. Refer to Listening Check on page 20.

Bone-Anchored Hearing Aids (BAHA)

Bone conduction hearing aids are often used in cases where someone has a malformed ear with no ear canal, or has chronic ear infections that do not allow for the use of traditional hearing aids with ear molds. The bone-anchored hearing aid, or the BAHA system, is surgically implanted and conducts sound through direct bone vibration. The BAHA consists of a small titanium implant, an abutment, and a sound processor.

The surgery is very minor and is often done under local anaesthesia. There is a period of three to six months following surgery during which the sound processor cannot be worn, in order to allow the implant to be integrated with the bone of the skull.

The sound processor can easily be snapped in and out of the abutment but allows for secure attachment.

It is important that the area surrounding the abutment is kept clean to avoid infection. This can be done using a soft brush.
Implantation is not recommended for children under the age of five because of the thickness and development of the skull. A BAHA Softband can be used for these children until they are able to undergo surgery. The Softband is an adjustable elastic band with a snap to fit the sound processor into.

**Cochlear Implants**

A cochlear implant is a device that is surgically implanted into the inner ear and that stimulates the hearing or auditory nerve directly, bypassing the damaged cochlea. It can provide useful hearing for individuals who have a severe to profound sensorineural hearing loss and who receive limited benefit from hearing aids. A cochlear implant will not restore normal hearing, but it will greatly improve access to sound.

**Components**

There are two components of a cochlear implant: an internal device and an external device.

The internal device consists of a magnet, a receiver, and a band of electrodes.

- During surgery, an incision is made behind the ear, and the magnet and receiver are secured in place under the skin.
- A hole is drilled into the inner ear and the band of electrodes is inserted into the cochlea.
- The skin is then stitched and the implant remains under the scalp of the individual.

The external device consists of a microphone, a speech processor, a transmitter, and batteries.

- The microphone picks up sound, which is then converted to an electric signal by the speech processor.
- The transmitter sends the signal through the scalp to the internal device using radio frequency.
- When the signal reaches the electrodes, they send out a small electric current that stimulates the auditory nerve and is interpreted by the brain as sound.
Candidacy

Not all individuals with hearing loss are candidates for cochlear implants. Any decisions regarding candidacy are discussed by the cochlear implant team.

Bimodal Hearing/Bilateral Implantation

Individuals with cochlear implants often wear a hearing aid in the opposite ear. This is known as bimodal hearing. For many of these people, a hearing aid will provide only low frequency information, but this is information that a cochlear implant does not always pick up. The hearing aid and cochlear implant work together to provide as much speech information as possible.

It is also becoming more common to receive bilateral cochlear implants, or one in each ear. Bilateral implantation can provide advantages in sound localization and speech discrimination in noise. The candidacy criteria remain the same for bilateral implantation as for single-sided surgery.

Acoustical Issues within the Classroom

Understanding speech in noisy environments can be difficult for any student, but for a student with hearing loss, it is even more challenging. Students need access to speech to develop their listening, language, and learning skills. Background noise, distance from the person speaking, and reverberation (echo) are common obstacles that significantly reduce the student’s access to crucial speech information. Although today’s advanced hearing aids can improve the quality, audibility, and clarity of the speech signal, they cannot remove all obstacles to speech understanding.

Students with hearing loss, even a mild hearing loss, may not express their inability to understand family members or teachers. They may not even be aware that they missed a question or misunderstood directions. If they are young and still learning language, they may be unable to tell when speech is unclear or buried in background noise. Students with hearing loss, and sometimes students with normal hearing, demonstrate difficulty in understanding speech when there is background noise, increased distance between the speaker and the student, and/or reverberation or echoes.
Ambient noise

is background noise, which competes with the main speech signal.

(Colorado School for the Deaf and Blind)

Noise

Ambient noise is present in most listening environments including classrooms. Hearing aids cannot selectively amplify only the speaker’s voice: they also pick up background sounds. In many difficult and noisy situations, hearing aids alone cannot make the speaker’s voice clearer or even louder. With background noise present, the loudness level of the speech signal may be barely above, and often may be lower, than the loudness level of the noise.

The comparison of speech and noise levels is referred to as the signal-to-noise ratio (SNR) and it represents the difference in loudness between the primary signal (e.g., a teacher’s voice) and the background noise. A student with a hearing loss needs the speech signal to be substantially louder than the noise—a higher SNR is required—even higher than the level required by his or her hearing peer in the same situation.

Distance

A student with a hearing loss has a reduced hearing range compared to a student with normal hearing. This hearing range can be referred to as a “listening bubble” (Anderson, ELF). As distance from the speaker increases (e.g., when listening to someone speaking from another room), loudness decreases. For the student with a hearing loss, distance becomes an obstacle to understanding speech. The greater the distance between the speaker and the listener, the less intense the speech signal becomes. This makes it more difficult for the listener to hear properly, since background noise often remains the same.

Research has shown that a student should be within one to two metres of the speaker for maximum speech understanding. This is not always possible to achieve either in the classroom or at home.

**Reverberation**

Another obstacle to speech understanding is reverberation or echo. When sound “bounces” off a surface, it can actually mask, or muffle, the main signal. It can reduce the clarity of speech, decrease the signal-to-noise ratio, and make speech more difficult to understand.

Using ceiling tiles, small carpeted areas, and muffling devices on the feet of chairs improves acoustic conditions in the classroom.

**FM Systems**

As mentioned earlier, distance, background noise, and reverberation make hearing difficult in a classroom. FM technology can be used in addition to the hearing aid(s) or cochlear implant(s) to overcome these factors. FM technology can be a personal FM system or a soundfield system.

- **A personal FM system** uses a transmitter, microphone, and receivers to send the teacher’s voice to the student’s hearing aid(s) by FM radio wave. The teacher wears a microphone and transmitter. The receivers attach to the student’s hearing aids directly or through an adapter called an AI boot or audio shoe. The student hears the teacher as if the teacher were standing right next to him or her, overcoming the problems of distance and background noise. Daily listening checks of the FM system are also needed. Refer to Listening Check on page 20.

- **Soundfield FM systems** use a microphone and transmitter to send the teacher’s voice to speakers in the classroom. Students with mild hearing loss or unilateral hearing loss benefit from these systems because the teacher’s voice is heard equally throughout the classroom and is louder than the background noise.

A soundfield system and a personal FM system can be linked to work together if both are needed in the same classroom.

The audiologist will select the correct hearing aids and FM system for the student. The teacher of the Deaf and/or hard of hearing (TD/HH) and the audiologist can provide support for the daily use of the hearing aids and the FM system.
FM Use with Cochlear Implants

Personal FM systems are compatible with cochlear implants and are generally recommended for classroom use. Noisy environments such as classrooms can make communication more difficult for students with any hearing loss, including those with cochlear implants, and FM systems can help to make communication easier.

Care of Hearing Aids and FM Systems

Hearing aids and FM systems should be kept clean, dry, and away from heat sources. They can be worn all day during sports and play, but care must be taken not to drop them on hard surfaces during handling or cleaning.

Over time, students learn to independently manage their amplification needs. In the Early Years, students may require assistance. The following suggestions are for staff who are completing the listening check.

To care for a hearing aid, a listening tube or stethoscope, a clean cloth, a battery tester, and an ear-mold blower are required.

To perform a daily listening check, become familiar with what the aid(s) should sound like to recognize a problem quickly if one should happen.

See page 20 for steps to follow to perform listening checks and to clean hearing aids.

Care and cleaning recommendations and troubleshooting guides for hearing aids/amplification equipment are available online at the manufacturer’s website. The TD/HH or the audiologist can provide printed copies or website addresses.
### Listening Checks

<table>
<thead>
<tr>
<th><strong>Hearing Aid</strong></th>
<th><strong>FM System</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Listening Check</strong></td>
<td><strong>Cleaning</strong></td>
</tr>
<tr>
<td>1. Test the battery with a battery tester before beginning the listening check.</td>
<td>1. Remove the ear mold from the hearing aid.</td>
</tr>
<tr>
<td>2. Have a supply of spare batteries and replace batteries as needed.</td>
<td>2. Wash the ear mold in warm water and mild hand soap.</td>
</tr>
<tr>
<td>3. Put the student’s ear mold into the bell end of the listening tube and insert the other end into your ear.</td>
<td>3. Rinse the ear mold in warm water, and dry well.</td>
</tr>
<tr>
<td>4. Turn the hearing aid on.</td>
<td>4. Use the ear-mold blower to force air through the ear-mold tubing. Be sure no water is in the tubing.</td>
</tr>
<tr>
<td>5. Say the following sounds into the hearing aid: /ah/, /ee/, /oo/, /sh/, /sss/, and /mmm/.</td>
<td><strong>Cleaning</strong></td>
</tr>
</tbody>
</table>

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Stethoset with hearing aid and ear mold

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