HEARING IMPAIRMENT

INTRODUCTION

Hearing impairment is one of the most common sensory disorders. It has been estimated that 10% of the population has some degree of hearing impairment, and hearing impairment is not unusual in people aged 65 and older. Over 40% of this population is affected by some degree of hearing impairment and this is a chronic problem. Most people who have a hearing aid had some level of hearing impair for 10 or more years before they sought professional help.

There are three basic types of hearing impairment and many different causes of this disorder. But regardless of the level of impairment or why it happened, hearing impairment can be a significant cause of social difficulties and it has been associated with a decreased quality of life, social isolation, and depression. Some hearing impairments are temporary and curable and some are permanent and irreversible. But there are ways of helping someone who has a hearing impairment communicate and Certified Nursing Assistants (CNAs) are often working with people whose hearing is impaired.

Learning Break: Some people who have hearing impairment have a profound level of hearing loss, but hearing impairment and deafness are not the same. Someone who is deaf has typically been deaf since birth or childhood and he/she was never able to socially interact
through hearing and speech. Assistive devices may give a person who is deaf the ability to recognize sounds but their primary form of communication is a manual language.

**STATEMENT OF PURPOSE**

This module will provide CNAs with information about: the anatomy of the ear; the process of hearing; common forms of hearing impairment, and; working with patients who have a hearing impairment.

**THE ANATOMY OF THE EAR**

The ear is comprised of three basic structures: the outer ear, the middle ear, and the inner ear. The outer, middle, and inner ear work together to take sounds from the environment and send them to the brain: this is the process of hearing.

**Outer Ear**

The outer ear, which is also called the **auricle** or the **pinna**, is comprised of three structures: 1) the auricle; 2) the auditory canal, and; 3) the tympanic membrane.

**Auricle**: The auricle, which is also called the pinna, is the structure that is generally referred to and thought of as the ear. It is the visible flap of cartilage and skin that is attached to the side of the skull. The primary function of auricle is to collect sound from the environment and direct it into the middle ear.
Ear canal: The ear canal is a short tube with a visible opening at the auricle. The ear canal is approximately 1 inch/2.5 cm long and it ends at the tympanic membrane. The function of this part of the ear is to funnel the sounds that have been collected by the auricle and transmit them to the tympanic membrane. The ear canal is where cerumen (ear wax) is produced. Cerumen helps to clean and lubricate the ear canal and it has some antimicrobial properties, as well.

Tympanic membrane: The tympanic membrane, which is also called the ear drum, is a thin sheet of tissue that separates the ear canal from the middle ear; it is the terminal end of the outer ear. The function of tympanic membrane is to transmit sound, in the form of vibrations, from the outer ear to the middle ear. The ear drum is aptly named; when it is seen by looking into the ear with an otoscope the tympanic membrane looks like the surface of a drum.

Learning Break: Examination of the tympanic membrane is often done to look for and diagnose otitis media. Otitis media is an infection of the middle ear that is common in young children and otitis media will cause the tympanic membrane to become red and swollen.

Middle Ear

The middle ear connects the outer ear with the inner ear. Important structures of the middle ear are: 1) the tympanic cavity; 2) the
ossicles; 3) the oval window and the round window, and; 4) the opening of the auditory tube.

**Tympanic cavity:** The tympanic cavity is a small space that separates the outer and inner ears. It contains the ossicles, the opening of the auditory tube, and the oval and round windows.

**Ossicles:** The ossicles are three tiny bones, the *incus*, the *malleus*, and the *stapes* that are suspended in the tympanic cavity. The malleus is connected to the tympanic membrane; the stapes is attached to the oval window, and; the incus connects the malleus to the stapes.

Sound waves funneled from the auricle and the auditory canal cause the tympanic membrane to vibrate. The malleus is physically connected to the tympanic membrane, and the vibrations of the tympanic membrane move the ossicles and transmit sound waves from the middle ear to the inner ear. The ossicles are very important for the process of hearing as they increase the vibrations of the tympanic membrane by a factor of 15-20. Sound moves through air much more efficiently than it does through a liquid, and the inner ear is filled with two fluids that are part of the transmission of sound waves, the endolymph and the perilymph. If the ossicles did not increase the vibrations of the tympanic membrane by a factor of 15-20 we would have a difficult time hearing very soft sounds.
Oval window: The oval window is a small opening that is covered by a thin, moveable membrane, and the oval window is part of the separation of the middle ear/tympanic cavity from the inner ear. The oval window receives sound vibrations from the tympanic membrane by way of the ossicles and transmits these vibrations to the inner ear. Round window: The round window is identical to the oval window; it is a small opening that is covered by a thin, moveable membrane and it is part of the separation of the middle ear/tympanic cavity from the inner ear. The round window works with the oval window to transmit sound vibrations to the inner ear.

Auditory tube: The auditory tube, which is also called the Eustachian tube, is a small tube that connects the middle ear to the nasopharynx. The pharynx is the part of the throat that connects the back of the mouth to the larynx; it cannot be seen by a visual exam because it is above and behind the oral cavity. The nasopharynx is the part of the pharynx that is closest to the nasal passages. The auditory tube has two openings, one in the bottom of the tympanic cavity and the other in the nasopharynx. The auditory tube drains mucous from the middle ear. It can also open or close as needed to adjust the pressure inside the tympanic cavity and this is important for normal hearing.

Inner Ear
The inner ear is where physical vibrations of sound waves that are transmitted from the middle ear are changed into nerve signals. These nerve signals in turn are sent to the hearing center of the brain.

The anatomy of the inner ear is very complex, it is difficult to convey in writing, and not easy to visualize even with the aid of illustrations. Understanding the anatomy of the inner ear is less important than understanding its functions, but some of the important structures of the inner ear will be reviewed and the description of these structures will also briefly mention their functions.

**Cochlea**: The cochlea is a complex, spiral shaped cavity of bone that looks very much like the shell of a snail. The cochlea has multiple compartments, and each one contains structures and fluids that are used in the process of changing sound vibrations into nerve signals, eg, the endolymph and perilymph and the organ of Corti.

**Organ of Corti**: The organ of Corti contains the hair cells. Hair cells, which will be explained next.

**Hair cells**: The hair cells are highly specialized cells located in the organ of Corti. Hair cells are the part of the inner ear that are directly responsible for changing mechanical vibrations of sound waves into a nerve signal that is sent to the hearing center of the brain.

**Endolymph and perilymph**: Endolymph and perilymph are fluids that are contained in distinct chambers of the inner ear. The endolymph
and the perilymph help change mechanical vibrations from the middle ear into a nerve signal by stimulating activity in the hair cells.

**Learning Break:** The inner ear is also responsible (in part) for helping us to maintain balance. Several inner ear structures, along with the sense of vision and the specialized parts of the nervous system, work together to help us maintain balance.

**THE PROCESS OF HEARING**

The process of hearing requires the coordination of many complex structures. Hearing is an intricate activity but the essence of hearing basically involves these two steps.

1) Transmission of the physical vibrations of sound, and
2) Changing the physical vibrations into a nerve signal.

In the first step sound begins as a vibration of air that creates sound waves. These sound waves cause the tympanic membrane to move and in turn, the incus, malleus, and stapes move the round window of the middle ear. The movement of the round window is transmitted by the endolymph and the perilymph to the hair cells. In the final step of hearing the hair cells change the physical vibrations received from the middle ear into nerve signals that are received by the hearing center in the brain. The stronger the sound waves are, the more the tympanic
membrane and the ossicles will move and the louder the sound will be.

A simple outline of the hearing process is illustrated below.

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Vibration of air
↓
Sound waves
↓
Physical movement of the tympanic membrane and ossicles
↓
Physical movement of endolymph and perilymph
↓
Movement is changed to nerve signals
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**Learning Break:** Some of these concepts can be difficult to understand as we don’t typically think of air as having any weight or force or imagining it vibrating. However, wind is moving air and it can obviously produce a lot of force. And think about the last time you were close to a very loud source of music. If the volume was high enough you could feel the sound as a vibration.

**Loudness** of a sound is determined by the amount of pressure a sound wave exerts on the tympanic membrane.

**Pitch** is determined by the speed and frequency of the sound vibrations. A sound vibration that is slow and with a low frequency is perceive as a low pitched sound. A sound vibration that is very fast and with a high frequency will be perceived as a high pitched

**Decibels** are the units that measure the intensity of sound - what we typically think of as how loud a sound is.
Table 1: Decibel Levels of Common Sounds

- Whisper – 30 decibels
- Normal conversation – 55-65 decibels
- City traffic hear inside a car – 85 decibels
- Jackhammer – 95 decibels
- Power mower – 107 decibels
- Power saw – 110 decibels
- Jet engine at 100 feet – 140 decibels

The decibel scale multiplies in intensity by a large factor for every decibel. This means that when a sound increases from one decibel level to another the perceived sound is much louder than you would imagine it to be from simply that increase. A useful way of understanding this is that when you increase the volume of a music source from 5 to 6 or from 9-10 the increase is proportional; it is a unit of one. But in the decibel scale if you increase the number of decibels from 50-60, for example, the 60 decibel sound is perceived as almost 10 times louder than the 50 decibel sound. This concept has important implications for hearing loss, especially for people who are exposed to noise at work. The Occupational Safety and Health Administration (OSHA) sets standard for noise in the workplace and the average background noise level in a workplace should not exceed 85 decibels for an eight hour day.
THE CAUSES OF HEARING IMPAIRMENT

Hearing impairment can be usefully divided into two categories:
Conductive hearing impairment and sensorineural hearing impairment.
Mixed hearing impairment is possible, as well.

Conductive Hearing Impairment

Conductive hearing impairment involves the outer ear or middle ear, and this type of hearing impairment is caused by a problem or problems with the physical transmission of sound waves - the conduction of sound waves - through the outer ear or the middle ear. Conductive hearing impairments may be temporary and reversible but some cannot be treated and will result in permanent hearing impairment.

The causes of outer ear conductive hearing impairment include:

- **Congenital defects**: The outer ear may be absent or severely deformed at birth.

- **Diseases/medical conditions**: Diabetes, diseases that cause an immuno-suppressed state, and certain dermatologic conditions may affect the ear canal.

- **Foreign bodies**: Foreign bodies can block the ear canal. Impacted cerumen is a very common cause of conductive hearing impairment.
- **Infections**: The ear infection otitis externa may cause temporary conductive hearing impairment when the ear canal becomes inflamed, swollen, and filled with mucus or pus.

- **Trauma**: Trauma to the outer ear can block the ear canal.

- **Tumors and lesions**: Tumors and bony growths may, if they are large enough, block the ear canal and cause conductive hearing impairment.

The causes of middle ear conductive hearing impairment include:

- **Congenital**: Some people are born with defects in one of the ossicles.

- **Infections**: Otitis media is very common in children and this infection causes fluid to build up in the middle ear, interrupting the normal transmission of sound waves. Otitis media is also common in adults, as well. In the great majority of cases otitis media is temporary and it is no more than a minor inconvenience. However, some children suffer from chronic ear infections and permanent loss of hearing is possible as a result.

- **Trauma**: Trauma, eg, a skull fracture, can cause a conductive hearing impairment by damaging the middle ear.
• **Tumors and lesions**: Cholesteatoma is an abnormal growth of the lining of the inner ear. This lesion is relatively common and can cause damage to some of the middle structures and a conductive hearing loss. Another relatively common middle ear lesion is otosclerosis. Otosclerosis is a bony growth on the stapes that interferes with normal functioning. Malignant middle ear tumors are rare.

• **Tympanic membrane perforation**: Tympanic membrane perforation, commonly known as a ruptured ear drum, is a very common cause of conductive hearing impairment. Tympanic membrane perforation can be caused by infection with a large buildup of fluid; trauma; loud noises, or; sudden changes in middle ear pressure, as can occur when diving or flying. Tympanic membrane ruptures usually heal by themselves and do not cause permanent hearing impairment.

**Sensorineural Hearing Impairment**

Sensorineural hearing impairment is caused by damage to the inner ear and causes an inability to change the physical vibrations of sound waves into nerve signals. Some of the causes of sensorineural hearing include:
• **Congenital**: Inner ear defects can be inherited and congenital malformations of inner ear structures occur, as well.

• **Disease/Medical conditions**: Common diseases such as diabetes, lupus erythematosus, and rheumatoid arthritis have been associated with sensorineural hearing impairment.

• **Infections**: Transmission of an infectious disease from the mother to the fetus can cause damage to the cochlea and sensorineural hearing impairment. Some of the more common of these infections are cytomegalovirus, hepatitis, toxoplasmosis, rubella (commonly known as German measles) or syphilis. Acquired infections such as meningitis and viral cochleitis can cause sensorineural hearing impairment, as well.

• **Medications**: There are many drugs that can cause sensorineural hearing impairment and some of the more commonly used ones are: aminoglycoside antibiotics, aspirin, diuretics such as furosemide, narcotics (eg, heroin, oxycodone) platinum-containing anti-cancer medications, and quinine drugs that are used to treat malaria. Maternal use of alcohol, illicit drugs, quinine, and retinoic acid
(topical preparations of vitamin A that are used to treat acne) can cause sensorineural hearing loss in a newborn, as well.

- **Meniere’s disease:** Meniere’s disease is a disorder of the inner ear. Meniere’s disease causes dizziness and vertigo and many people who have Meniere’s eventually develop some degree of hearing impairment.

- **Noise:** Both sudden loud noise and sustained noise above a certain level can cause sensorineural hearing impairment. Noise-induced hearing loss is the second most common cause of sensorineural hearing loss. The degree of noise-induced hearing impairment is directly related to the level and duration of noise exposure.

- **Presbycusis:** Presbycusis is the medical term for age-related hearing loss. This is the most common cause of hearing loss and it will be discussed in a separate section of the module.

- **Trauma:** Trauma to the skull and trauma caused by sudden changes in ambient pressure (as can occur in flying or diving).

- **Tumors:** Inner ear tumors are usually benign but they can cause inner ear damage.
Presbycusis

Presbycusis affects more than 50% of all adults 75 years and older and as previously mentioned, it is the most common cause of hearing loss. It occurs more frequently in men than in women; this difference is probably because occupational noise exposure is more common in men.

Presbycusis develops slowly over many years and for this reason presbycusis may go unnoticed. It typically affects both ears. The exact cause/causes of presbycusis are not known, but it is thought to be the result of damage to the hair cells, damage to the blood supply of the inner ear, or damage to specific nerve cells of the inner ear, and the abnormal changes in these structures are probably caused by a complex interplay between genetic susceptibility and exposure to environmental risk factors. Environmental risk factors that contribute to the development of presbycusis include: diabetes; hypertension, infections; noise exposure; ototoxic drugs, smoking, and vascular disease.

Specific hearing changes associated with presbycusis include a decrease in hearing sensitivity; inability or decreased ability to, locate sounds; inability or decreased ability to detect high-pitched sounds; decreased ability to understand speech if there is background noise; an inability to tolerate loud noises, and; slow processing of sounds.
Because of these changes people who have presbycusis will often be able to detect only certain parts of speech and will be unable to hear speech that is produced at specific frequencies. The result would be similar to someone who can read but can only recognize every fifth or sixth word.

People who have presbycusis may also develop tinnitus (ringing in the ears), vertigo, and balance problems. Significant hearing impairment is common but complete hearing loss is rare.

**EVALUATION AND ASSESSMENT OF HEARING**

The evaluation of someone for hearing impairment should begin with a patient interview. Important information that should be gathered is:

1. When did the hearing problem start?
2. Was the onset sudden or gradual?
3. What is the nature of the hearing problem, ie, does it occur when there is a lot of background noise, is it a problem hearing conversations? Does it interfere with your job?
4. Was the patient ever exposed to loud noise, either sudden loud noises or continuous loud noise at her/his job?
5. Did the patient ever receive treatment with an ototoxic drug or is he/she being treated with one now? What medications is the patient currently taking?
6. Does the patient have any chronic medical problems?
7. Has the patient ever had an ear infection or trauma to the ear or head?

8. Is the patient dizzy or have tinnitus or vertigo?

9. Does the patient report any pus or drainage coming from the ears?

This list can obviously be expanded but the intent of the patient interview is clear; determining the nature of the hearing problem and trying to find out the cause.

Following the patient interview the visible structures of the ear should be examined and the ear canal should be visualized using an otoscope. Particular attention should be paid to the tympanic membrane; it should not be red or swollen.

The next step in the evaluation is to perform hearing tests. There are several hearing tests that can be done by a primary care physician or a nurse practitioner but for a complete hearing evaluation the patient requires a formal audiologic assessment by an audiologist. Two basic hearing tests that can be done by an experienced clinician are:

- **Whispered voice test**: The clinician stands behind the patient, covers one of the patient’s ear by blocking the ear canal, rubs the tragus (the small flap of skin that protrudes back over the ear canal) and then whispers a short sequence of letters or numbers. The patient is asked

- **Tuning forks**: A tuning fork looks somewhat like a fork used for eating
except it is much thicker, shorter, and has only two tines. When the tuning fork is struck against a hard surface it vibrates and produces a soft, constant humming sound. The end of the tuning fork is placed on several areas of the patient’s skull or close to the ear canal and the patient is asked how well she/he can hear the hum and when it stops. The tuning fork test is used to determine if there are conductive hearing impairments. Example: The tuning fork is placed on the mastoid bone (the bone behind the ear) and held in front of the ear canal. If the sound is louder when the tuning fork is placed on the bone then the patient probably has a conductive hearing impairment.

An audiologic examination is an essential part of a hearing evaluation. This examination typically has four parts:

1. Pure tone testing: The patient wears earphones, a range of tones is transmitted through the headphones, and the patient indicates which one he/she hears.

2. Air/bone conduction: Using special apparatus, the patient’s ability to detect sound through bone and air is tested.

3. Word recognition: The patient wears earphones and the audiologist recites a list of words. The patient is asked to repeat each word as it is spoken.

4. Speech audiometry: Speech audiometry has two parts, speech reception threshold and the word discrimination score.
For speech reception threshold the patient is tested to determine the softest level at which he/she can hear a series of words, words such as airplane that have both syllables stressed when they are spoken. In word discrimination the patient is tested to determine the softest level at which she/he can recognize a series of phonetically balanced words.

**PREVENTION OF HEARING IMPAIRMENT**

Aside from avoiding excessive noise there is little that can be done to prevent hearing impairment and routine, preventative screening for the early detection of hearing impairment is not recommended for adults. For infants and children however, screening for hearing impairment is very important. Hearing loss is the most common congenital condition in the United States, and each year approximately three in every 1000 infants born in the United States will have moderate, severe, or profound hearing loss. Hearing testing for newborns is mandatory in all 50 states and it should be done before the child has reached three months of age.

But although hearing screening for adults is not recommended, there are warning signs that indicate the presence of hearing impairment. If any of these are present a hearing evaluation should be done.

**Table 2: Signs of Hearing Impairment**

- Difficulty in hearing soft-pitched speech
Asking people to repeat what they have said
Difficulty hearing conversation if there is background noise
Cupping a hand behind an ear in order to hear
Insisting that people mumble or don’t speak clearly
Avoiding social situations because you can’t hear conversation
Ringing or buzzing in the ears
People complain that your television or radio is too loud
You are embarrassed to meet people because you can’t hear well
You have changed your life activities because your hearing is poor

**TREATMENT FOR HEARING IMPAIRMENT**

A full discussion of the therapies that can be used for hearing impairment would be quite extensive; this module will focus on treatments that are available for presbycusis, the most common form of hearing impairment.

Presbycusis can’t be cured but its impact on hearing and quality of life can be lessened by the use of lip reading, amplification devices, assistive listening devices, and cochlear implants.

**Lip Reading**

Lip reading, which is also called speech reading, can be a helpful tool for people who have a hearing impairment. Lip reading involves observing the movement of someone’s mouth and lips when he/she speaks; understanding of the context in which a conversation is taking
place, and; observing the facial expressions and body language of the speaker.

Example: You have a hearing impairment and you are meeting someone for the first time. You are attending a crowded party at a restaurant and there is a lot of background noise. This new acquaintance extends his hand, looks you in the eye, smiles, and speaks to you. You hear some of what is said but not all of it, but you distinctly hear the words “. . . it’s a pleasure . . . “ Based on the context, your life experience, and the body language and facial expressions in use, you respond: “It’s a pleasure to meet you, too.” Lip reading is a useful tool to have for the person who is hearing impaired, but of course it cannot take the place of normal hearing and it is a skill that takes time and practice to master. In addition, it is not possible to use lip reading to understand everything that is being said, especially if someone is speaking quickly and does not speak clearly.

**Amplification Devices**

Amplification devices, which are commonly called hearing aids, are commonly used for people who have presbycusis. Hearing aids can be worn behind the ear (the standard and the mini behind the ear types) and there are much smaller models that fit in the ear or in the ear canal. Despite the difference in size and location of placement, all hearing aids work in the same way. A microphone picks up
environmental sounds; an amplifier increases the level of the sounds, making them louder; a receiver delivers these sounds into the ear, and; a battery provides a power source.

Hearing aids are expensive and they do require a period of adjustment. In addition, hearing aids work by amplifying sounds - all sounds - and they do not help the user discriminate one sound from another. Given that, someone who had presbycusis and is fitted with a hearing aid can hear conversation at a louder level but he/she may not be able to understand what is being said and will hear a lot of unwanted noise as well.

However, a hearing aid will increase a patient’s ability to converse and socialize and there are few people who have presbycusis who cannot be helped by a hearing aid. A well-fitted hearing aid can be comfortable and unobtrusive, and studies have shown that a hearing aid can help lessen the emotional problems and social isolation that are associated with presbycusis.

**Learning Break:** Caring for a hearing aid is not difficult. When it is not being used, store it in a clean, dry area, away from moisture. Do not get a hearing aid wet or expose it to direct sunlight. Clean the outside of a hearing aid and remove any cerumen buildup by using a soft cloth or a tissue and warm water; do not use cleaning solutions or solvents. Finally, make sure that hearing aid batteries and the hearing
aid are kept somewhere that is inaccessible to children. A hearing aid battery can easily be swallowed by a child - many are just a bit bigger than ¼ inch in diameter and they are very thin – and a swallowed hearing aid battery can cause very serious harm.

**Assistive Listening Devices**

Assistive listening devices are used to increase the volume of sound for the hearing impaired. There is a wide variety of these devices; they can be very simple, such as an amplifier for telephones or relatively complex and sophisticated such as a system that changes the sound from a television into infra-red waves that are sent to a special receiver used by the person who has the hearing impairment.

**Cochlear Implants**

A cochlear implant can be used if a hearing aid is not sufficient for someone who has presbycusis, and a cochlear implant can be very effective for people who have severe bilateral presbycusis.

A cochlear implant has two components: the external microphone, sound processor, and transmitter, all of which are placed behind the ear, and; the surgically implanted receiver. A cochlear implant transmits sound and sends it by way of the implant to the cochlea. Once the electrical impulse reaches the cochlea the implanted receiver sends a nerve signal to the hearing center of the brain and the hearing process is complete.
HELPING A PATIENT WHO IS HEARING IMPAIRED

Your pattern of speech may need to be adjusted when you are talking to someone who has a hearing impairment. This will be a process of trial and error but it doesn’t require special techniques, simply patience and common sense.

1. Stand directly in front of your patient when you are speaking; this allows them to see your facial expressions and to lip read. It is also helpful if the conversation takes place in a well-lit area.

2. Eliminate background noise, if possible, or have the conversation some place where there is no background noise.

3. You will almost certainly have to speak louder than you normally would. However, if you notice that your volume of speech seems too loud it probably is and shouting will not help a person who has presbycusis hear what you are saying.

4. Speak slowly and if possible use short and simple sentences. Avoid complex words if a basic one will suffice.

5. People who have presbycusis have difficulty with high-pitched sounds. If someone does not seem to understand what you are saying try lowering your voice.

6. Conversation is a back and forth process but a person who has presbycusis has trouble receiving aural information. In
addition someone who has presbycusis may pretend to hear what you have said because he/she may be embarrassed or self-conscious about his/her inability to hear. When you are speaking to someone who has presbycusis - or any hearing impairment for that matter - think of it as sending and receiving information and confirm that what you have said has been understood.