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NCHAM
INTRODUCTION TO AUDIOLOGY AND HEARING LOSS FOR NON-AUDIOLOGISTS
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>> You have reached the sign on for today's webinar, the introduction to audiology and hearing loss for non-audiologists, brought to you by the National Center for Hearing Assessment and Management at Utah State University, NCHAM, which is what the National Center for Hearing Assessment and Management is known as.

It serves as a national resource center on early hearing and detection.

We are just about at the bottom of the hour, I am seeing people continuing to rapidly sign-on.

So I think we should hang tight for a minute or two longer, and then we will get started.

Again, you have signed on for today's webinar by the National Center for Hearing Assessment and Management at Utah State university, also known as NCHAM. We serve as the national center for early detection and intervention funded by the office of Head Start and the maternal Child health Bureau.

Today's webinar is entitled introduction to audiology and hearing loss for non-audiologists.

I keep saying the same things over and over again just so that those who are signing on have an opportunity to adjust their

speakers and get settled in, so sorry for the repetitiveness, but it is for that purpose that I am continuing to do this.

Jeff and Terry, you about ready to get started?

>> I think we are.

>> I am ready.

>> Okay, I am going to go ahead and initiate the recording of today's webinar, so I'm going to pause for just a moment to do that. Well I do that, Jeff, would you mind removing the note that is on the current screen?

>> I will do that, yes.

>> Thanks.

[Audio recording for this meeting has begun]

>> Good day, everybody. My name is William Eisenman, and I am the associate director for the National Center for Hearing Assessment and Management at Utah State University, also known as NCHAM which serves as a national resource Center on the early hearing detection and intervention at Utah State University and is funded by the maternal Child health Bureau, and also by the office of Head Start to support quality early hearing detection and intervention practices in a variety of different venues.

Today we are you a webinar which is entitled introduction to audiology is -- audiology and hearing loss for non-audiologists presented by Terry Foust and Jeff Hoffman, both of whom are audiologists.

Jeff is on the staff at NCHAM, I really working in our early childhood hearing outreach initiative, also known as the Echo initiative that focuses on promoting continuous screening throughout early childhood period.

Terry Foust has been a long-term consultant with NCHAM working in many different capacities with NCHAM over the years.

We are really fortunate to have the two of them here today to present this topic which was provided at a previous -- at last year's EHDI conference.

Without further ado I would like to turn it over now to Jeff and Terry, introduction to audiology and hearing loss for non-audiologists.

>> Thank you very much, William, and as William said I am Jeff Hoffman, audiologist with the national Center for hearing assessment in the early outreach initiative, and it is a pleasure to be today.

Terry, would you like to say hi?

>> Yes, good morning or afternoon to all of you, I'm glad to be with you, and I hope that this will provide information that will be useful in all of the areas you work with with child hearing.

>> Thanks, Terry.

These are our disclaimers, and we will go ahead and start with the learning objectives for today, the anticipating outcomes for this webinar that you will be able to describe the important aspects of hearing and hearing loss, to explain how hearing loss is assessed and diagnosed, outline the types of treatment and intervention for hearing loss, describe the impact of hearing loss on early development, and explain how audiologists monitor and manage hearing loss.

As we begin our discussion about hearing and hearing loss, I would like to take just a moment to explain the roles that audiologists fulfill in working with people with hearing loss.

Audiologists are specialists in both hearing and balance. One key aspect of an audiologists work is the prevention of hearing loss, and the other primary areas for audiologists are the identification and assessment of hearing and balance problems, as well as the rehabilitation of hearing and balance disorders.

When working with young children, including newborns, the primary focus of audiology is on hearing.

We will take a quick look at the ear and how it works. In the slide you see a cross-section of the ear showing many of the important structures, and we will zero in on each part of the ear and how it contributes to hearing as we go through the slides of the next couple of minutes.

There are four main parts of the auditory system; the outer ear, middle ear, in her ear, and the central auditory nervous system.

The flesh he part of the outer ear that we see is called the pinna, and it does not really serve much purpose with regard to hearing.

The next part of the outer ear that we see is the your canal which is about an inch long and has a slight S-curve to it.

Be your canal serves to channel sound from the outside environment to the auditory system, as well as to produce earwax or cerumen.

The eardrum or the tympanic membrane is the boundary between the outer ear and the middle ear, and the your job vibrates when sound hits it and sound energy is converted to mechanical energy.

It also increases the strength of the sound as it transmits those vibrations to the middle ear.

He was a photograph of a healthy tympanic membrane or eardrum. You notice it is a purely color and somewhat transparent. In fact you could just begin to see one of the middle ear bones beginning at the center of this picture and progressing up to about the 1 o'clock position, the operating position there.

The next part of the ear as we move inward is the middle ear. The middle ear is essentially the air-filled cab any beyond the eardrum and it contains very small bones. The sponsor connected by ligaments, and they also have some very small muscles attached to them.

When transmitting sound vibrations from the eardrum to the inner ear, the three boats also increase the strength of those vibrations.

It is another part of the middle ear, the eustachian tube, interconnect fear to the back of the throat. It maintains the same air pressure at the environment.

Many of you have flown in an airplane, and hopefully you have experienced the eustachian tube opening and closing when you have chewed gum or swallowed when you are trying to clear your ears while the plane is gaining altitude or landing. That

clearing of your ears is a result of the eustachian tube opening and closing.

In this photograph you can see how small the inner ear bones are in comparison to a dime. Left to right in this photograph, the bones are the malleus or the hammer, the Incas or also called the anvil, and the stapes or the startup.

The malleus taxes to the eardrum, the Incas connects the malleus to be stapes which is the smallest bone in the body.

And then the footplate, the end part of the stapes inserts into what is called the window of the cochlea or the inner ear but we will see in just a moment, and this causes vibrations of the fluid in the middle ear.

Excuse me, the fluid in the inner ear.

The inner ear consists of both hearing and balance structures. The hearing part of the inner ear is called the cochlea, and it is the small snail shaped structure that you see in this diagram over on the right side.

There are three chambers to the inner ear that are filled with fluid. There is also a structure called the organ of Courtney, and many thousands of tiny sensory organs called hair cells.

Through the action of the hair cells and other parts of the cochlea, the mechanical vibrations that have been transmitted by the outer and middle ears are changed to small electrical signals.

Here is a diagram of the organ of Courtney. It is the end organ of hearing, and the vibrations transmitted to the middle or ear boats that move the fluid of the inner ear cause these nerve endings which are shown as the green structures in the diagram to bend, and it is through this pending action that the electrical or nerve impulses are generated and sent to the fourth part of the auditory system which is the central auditory system.

The green structures in the previous slide are called hair cells, and this is a micrograph of the hair cells. The hair cells respond to specific frequencies or pictures because of their placement in the cochlea.

There are many thousands of these hair cells, and they are organized in three rows of outer hair cells and one row of inner hair cells, and you can see those four different rows of hair cells in this micrograph.

Terry is going to talk a little bit more later about how the otoacoustic emissions or AE are generated by the outer hair cells when he is talking about the testing of hearing.

The last part of the auditory system consists of the auditory nerve and the central auditory system in the brain.

The electrical nerve impulses that were produced in the cochlea by the hair cells are transmitted and processed by this auditory nerve, which consists of over 25,000 nerve fibers.

The signal, the electrical signal continues through the brainstem up through the auditory cortex of the brain, and it is up at this level of the auditory cortex that sounds are interpreted based on experience and association, and meaning is assigned to that initial sound that travels to the outer and middle and inner ears.

Now that we have had a quick overview of the ear and how it works, we will spend a couple of minutes talking in a bit more detail about what happens when there are problems with one or more parts of the auditory system.

For the next few minutes we will talk about the different types of hearing loss.

The first way to describe hearing losses by identifying the number of ears involved. If a hearing loss is present in only one ear, it is a unilateral hearing loss.

But if both ears are involved, then that loss is called a bilateral hearing loss. So one ear is unilateral, two ears are bilateral.

Audiologist will also identify the types of hearing loss based on what part of the auditory system is involved in creating the hearing loss.

If the loss occurs in the outer or middle ear, it is called a conductive loss.

If the hearing loss is a result of problems in the inner ear, it is called a sensory or a sensorineural hearing loss.

And if it is a mix to loss, that results when there is a problem in the outer and/or middle ear and the inner ear, so in next loss as both a conductive and a sensorineural component.

Hearing problems that occur beyond the cochlea fall into the neural or sensorineural categories. Terms you might see for hearing problems be on the cochlea are auditory neuropathy spectrum disorder, auditory neuropathy dyssynchrony, and central auditory processing disorders.

Problems in this part of the auditory system often require additional testing beyond the basic otologic testing to identify hearing loss, and we are going to spend a bit more time here looking at each type of these hearing losses.

Each year the Center for Disease Control and Prevention, the CDC, surveys the states' newborn hearing screening programs, also known as the EHDI programs, early hearing detection and intervention programs.

To get statistics about their state and territories 1,3,6 results, that 1,3,6 is newborn hearing screening by one month, otologic evaluation by three months, and intervention by six months of age.

For 2013, which is the most recent year that results are available, it was reported that 40 percent of the permanent congenital hearing losses identified in babies were unilateral losses.

A unilateral hearing loss does have a significant impact on development even if the one ear has normal hearing.

When there is noise on the side with the good ear, a child with the unilateral loss will not be able to access speech or sounds that are nearer to the ear with the hearing loss.

So this child might miss out on instructions or other important information.

Although the developmental impact of the unilateral hearing loss may not be apparent initially, research has shown that by the time a child is in elementary school, about third or fourth grade, a child with a unilateral hearing loss does not receive -

- who does not receive any intervention are typically functioning at about the 10th to the 40th percentile in math, language, and social skills. So the unilateral hearing loss does have an impact on the child's later academic performance.

A hearing loss in both ears is of course going to have a much greater impact on a child's development during the early years if there is not any intervention because book language development depends on access to sound.

Bilateral hearing losses are more common than unilateral hearing losses in early childhood, and as you can see from these CDC statistics here, 60 percent of the babies identified with permanent congenital hearing loss at a bilateral loss.

We're going to take a look at the different types of hearing loss with the CDC surveys.

Conductive hearing loss results from problems in the outer and/or middle ear. Not being able to conduct the sound, it can be either temporary or permanent.

Medical treatment of the underlying cause of the conducted hearing loss often results in hearing returning to normal or near normal.

For example, if the ear canal is plugged with earwax or a foreign object, some hearing loss will occur until the blockages removed.

The amount of hearing loss would be similar to having an earplug in your ear canal.

Many in children experience one or more middle ear infections during early childhood, and these ear infections, which are often referred to as otitis media, can be painful for the child. And if the middle ear space fills with fluid, there is a temporary hearing loss until that infection is resolved and the fluid is gone.

But sometimes untreated middle ear infections can cause some other middle ear problems which result in a permanent hearing loss also.

But if a child is born with malformations of the outer or middle ear, oftentimes surgical treatment may not happen for several

years and the child's hearing ability could improve after the surgical interventions.

As you can see at the top of the slide, only a small percentage, 14 percent of the babies born with permanent hearing loss are reported in that annual CDC survey to have been a conductive loss.

A sensory or sensorineural loss, hearing loss from problems in the cochlea or the inner ear, are almost always permanent.

There are many different causes of the sensorineural hearing loss. Some of the causes can be genetic or syndromic, may be the result of medications or infections or high fevers or head trauma.

Sensorineural hearing losses can be categorized in several different ways. When the hearing loss is present at birth, it is called a congenital hearing loss.

But sensorineural hearing loss can and does occur at any time across the lifespan, and those sensorineural hearing losses are called later onset or acquired sensorineural hearing loss.

If the hearing loss continues to get worse, it is called a progressive hearing loss. And as you can see from that statistic up there, about two thirds of the permanent congenital hearing losses reported to CDC were sensorineural, and that makes it by far the most common type.

A mixed hearing loss has both a conductive component and a sensory component. So the conductive component is a result of the problem in the outer or the middle ear, where the sensory or sensorineural component results from a problem in the inner ear. So the mixed hearing loss is both a conductive component and a sensorineural component.

Permanent mixed hearing losses at birth are somewhat rare. Only 8 percent of those reported to the CDC were mixed hearing losses.

Auditory neuropathy spectrum disorder involves the disordered transmission of the electrical or the nerve signal along the acoustic nerve.

Auditory neuropathy spectrum disorder, also known as auditory neuropathy dyssynchrony, is also relatively better in the new

were population. Only about 5 percent of those reported to CDC from the newborn hearing screenings is a result of those.

Central auditory processing refers to how will the central nervous system uses auditory information.

Disorders of the central auditory processing system can include problems with determining where the sound is coming from, and excessive difficulty understanding speech and auditory signals, especially in poor listening conditions such as noisy settings.

These disorders may come exist with other disorders such as ADHD or language impairment or learning disorders, but that auditory -- that central auditory processing problem is not the result of these other disorders.

We know that about one third of children will have repeated middle ear infections by three years of age, which is usually accompanied by temporary conductive hearing loss.

But how many young children have a permanent hearing loss? Nearly all babies born in the United States have their hearing screened within the first few days of life. And as I mentioned earlier, every year each state and territory reports the results of the state's newborn hearing screening and hearing loss identification to the CDC.

These results have shown that the prevalence of congenital hearing loss is about 1.5 per 1000 babies born in the United States, and the congenital hearing loss is the most common birth condition.

These are only the numbers that are confirmed, that 1.5 per 1000, and nationally about 32 percent of the newborns who do not pass the newborn hearing screening are not getting the necessary follow-up evaluations.

So there is really most likely quite a few more congenital hearing losses then we know about.

Hearing loss can and does occur at any time in a person's life. The Echo initiative has collected screening results on over 25,000 children in the last decade, and these are children up to three years of age.

The first to publish results in 2008 found that about the same rate, 1.5 of every 1000 early head start children screened using

otolaryngologic screening had a previously identified hearing loss.

Terry Foust and colleagues found a higher rate of previously unidentified permanent hearing loss in a study that they did in health clinics, and that was 3.5 per 1000, and that is previously unidentified hearing loss.

So the rate of permanent hearing loss continues to climb as children get older. And so what causes this permanent hearing loss throughout early childhood.

In 2006, Morton and Nance published an article entitled newborn hearing screening, a silent revolution, in which they discuss the causes of permanent hearing loss at birth and at four years of age.

In this chart, it shows the causes of congenital hearing loss, and this is from their article. As you can see near the top, the incidence of permanent hearing loss at birth was nearly 2 per 1000 in their study, and you can see in the red circle area there that the mutation of the GJB2 gene is responsible for about 20 percent of the hearing losses at birth, but that is not the only cause of congenital hearing loss.

Causes of hearing loss associated with various syndromes including [indiscernible] syndrome account for about 17 percent of congenital hearing loss, and an additional 30 percent of the congenital hearing loss is due to unspecified syndromic genetic factors.

So combined, genetic factors combined for over two thirds at 68 percent of the permanent hearing losses that are present at birth.

Cytomegalovirus or CMV is also a leading cause of congenital hearing loss, and that account for about 21 percent of the hearing loss is present at birth.

About half of the children with hearing loss due to CMV sure whether signs of congenital CMV, and that could be vision loss, small head size, problems with the liver, spleen, the lungs.

But the other half showed no other signs of congenital CMV other than hearing loss.

By four years of age, we see that about 50 percent of the hearing losses are due to genetic factors, but there are other causes that have also been added into the mix.

Congenital CMV still accounts for about one fourth of all permanent hearing losses, although we now see that there are some late onset hearing losses due to congenital CMV that are being identified.

Notice how many children at four years of age now have a permanent hearing loss up here at the top, it is almost a 3 per 1000 compared to 1.5 per 1000 at birth.

So what are the implications that this increase in permanent hearing loss throughout early childhood, what are the implications on hearing screening? Is screening at birth and then at school entry enough?

No, because permanent hearing loss can and does occur at any time. So how often should hearing be screened during early childhood?

We recommend that a child's hearing be assessed at least annually in the early head start programs that the ongoing initiative works with. And that is an effort to catch any changes in hearing that may be occurring and to get that identification and intervention going as soon as possible.

We have found that some early childhood programs, however, choose to screen children semiannually, twice a year.

So additionally whenever a parent or caregiver has a concern about a child's hearing, rescreening and even perhaps a complete otologic evaluation is in order.

This is a good segue into the next topic, screening and diagnostics, which Terry is going to discuss. So Terry, I am going to turn it over to you.

>> Thank you, Jeff.

Thank you for covering the causes and the types of hearing loss.

Now we want to talk about the tests that we will use to determine hearing status.

You commonly hear of references to various tests, and so we hope that by the end of this part of our discussion, you will be familiar at least with those tests and what they are looking at.

Before we go on to the tests, Jeff had referenced the JCIH, the joint committee on infant hearing, the hearing screening guidelines, and this joint committee is a committee of experts across different clinical disciplines including audiology, otolaryngology, pediatrics, [indiscernible], and his group of experts has made ongoing recommendations that have set the standard for hearing screening and follow-up that we follow.

As Jeff mentioned, we have the 1,3,6 model which is by one month we want to have hearing screened, by three months we want to evaluate the hearing and complete all of our diagnostic and otolaryngologic, and we will talk about these tests we will want to use by this three-month period.

By six months and role in early intervention services.

And again, the reference by is really a minimum. If we can do this earlier, that's best.

Why is it important to do it so early? It is really because that rate of growth and development in the first year of life is unmatched at any other time during postnatal development.

These findings are supported by brain imaging techniques, techniques such as this PET scan that you see here on the slide.

As a baby grows, their brain is developing and the tiny synapses which are electrical synapses forming. The amount of stimulation that a child receives directly impacts the amount of synapses that are formed within their brain.

The creation of the synapses are virtually complete after the first three years of a baby's life. So I really want to emphasize that these first years of life are the most important brain development, and we want to get that auditory stimulation in there just as soon as we can.

Let's go ahead and talk about the hearing tests that we do, that we use, and these are the hearing tests we want to use to meet those time criteria.

These hearing tests are going to help us determine how significant the hearing loss is, so how much hearing loss is there. Is it mild, moderate, severe, or profound.

We also want to determine the kind or type of hearing loss, and this is in reference to what Jeff talked about; is the hearing loss conductive or a problem in the conduction of the sound through the auditory system.

Is it sensorineural meaning the sensory organs of the inner ear maybe where the problem is.

So really when we determine the kind or the type, we also determine if we can, the location in the auditory pathway of where we have the hearing loss.

We want to determine the configuration which is really what does that hearing loss look like? Is it better at some frequencies or pictures, or worse in others.

And then we use all of that information to help us make decisions on treatment and intervention, which we will talk about a little bit later.

I want you to walk away today understanding that we really have four main tests.

Just think of this as working from the outside in.

We have tympanometry, which are commonly referred to as a tympanogram. So in reports and things you read, you may hear people say tymps or tympanogram, and what that really is is it is a test of middle ear function it really looks at how the eardrum and middle ear are working.

The second one, going further into the system -- so we start with the middle ear and now we are in the middle ear -- is on acoustic emissions. The otoacoustic emissions test how the inner ear or cochlear is functioning, and specifically the little tiny hair cells that are in the inner ear, the outer hair cells, how they are functioning.

We have gone from the middle ear now into the inner ear and the next test is auditory evoked responses or ABR, and you will commonly hear it as A-BEAR or a testing which are just different acronyms for the same test.

This looks at testing the hearing nerve and the auditory pathways of the brain in response to sound, and we use that to look at the quietest level of sound that a child's CS auditory system, that better response to.

That we pull all of that together, and this is where we move from that stimulation has gone from middle ear, inner ear, to the auditory pathway, and then it is interpreted in meaning and some third of a response.

So it is either a response for the sound is detected in the head turns, or it could be right up to a play type of task where a child listens and places a toy in a bucket in response to the sound.

That behavioral testing uses age-specific sound techniques for us to observe their response to sound.

We work our way from the outside in. And before we go any further, I did just want to talk about objective versus subjective tests.

Subjective tests do not require a behavioral response. We are not looking for a behavior from the child, and we use it to determine the status of the auditory system.

So those first tests that we talked about, middle ear function, inner ear function, the function of the central or the auditory pathways, those are all objective tests.

And if we were altogether, I would say or quiz you for the names of these. So middle ear function would be tympanometry, tympanogram or tymps or other commonly used words.

Inner ear function would be otoacoustic emissions.

And the central auditory pathways would be auditory brainstem response testing.

So back your with these tests, and that behavioral is a subjective test, it is not objective, and we will discuss that in a little bit.

To specifically review with tympanometry, there are just a couple of things I want you to walk away with understanding here.

Tympanometry is an objective test of middle ear function. And it helps us determine whether a hearing loss is sensorineural or conductive.

So really how we test for a tympanogram is we put a small probe into the ear canal, and that small probe will put in a small sound and also puts pressure into the ear, and we do a pressure change and then we measure the response of the eardrum and the sound that is reflected.

And we can tell by that movement how the middle ear is functioning.

We use that information for several things. It can let us know, for example, if there is fluid behind the eardrum because we do not get normal movement in that case.

It can let us know if there is a whole or perforation in the eardrum because we can -- by measuring the volume, we can tell if that is normal or not.

And we can also get normal eardrum movement.

The equipment for all of these tests may be somewhat complex, but this just gives you an idea of what we would have with the equipment to measure those items.

This is just a graphic of the types of equipment, but really all we need to know is that we have a probe that goes in the ear, it puts in some sound and pressure, and it moves that system, and we determine whether that is normal or not.

With otoacoustic emissions, and what we need to know is that otoacoustic emissions are small sounds generated by the inner ear that can be recorded in the your canal with a small microphone.

These are sounds that we measure that are generated by the outer hair cells in the cochlea where the inner ear when we stimulate them.

The measurement of otoacoustic emissions is a relatively recent addition to our audiological test batteries when we compare it with the other tests.

It was really discovered by David Kemp in England in the late 1970s, but it was not really seen as a routine part of clinical testing until the late 1990s.

It's a great screening and diagnostic test, and they are typically not present in hearing losses that are as mild as 30 decibels.

They do not tell us anything about the degree of hearing loss, but they do let us know if there is a problem at a pretty quiet level.

Just to review here, again you measure and otoacoustic emission by putting a small probe into the ear canal.

There are some sound stimulation presented and a very tiny sophisticated microphone measures the response of that inner ear, and we are able to tell if that response is present and normal.

I hope that everyone can see this, but we are going to go ahead and play a small graphic here, and if you can see that, the stimulation goes in; stimulation goes in, it stimulates and moves that middle ear system, and then the inner ear, and then we measure the emission coming back out.

I will played one more time. Middle ear, inner ear, and the emission coming back out.

Now let's go further up the auditory system.

We are going to talk about auditory evoked potentials, and the most common acronyms you will hear are ABR or A-BEAR, and what we really want to talk about here is that the auditory brainstem or auditory even vote potentials, these tests measure the reaction of parts of the child's nervous system that affect hearing. So again, the auditory pathways.

It measures the ear's and pathway's response to sound.

A couple of things to remember. The auditory test is safe, it does not hurt, and it can be completed only if the child is sleeping, flying perfectly still and relaxed with his or her eyes closed.

So it does require that the child be very still.

If the child is younger than six months of age, it can usually be done while he or she is napping. Sometimes we use strategies to keep them awake or somewhat sleep deprived so that they will sleep when we do the test.

But if they are older than that between the ages of six months and sometimes up to seven years, the ABR test is done under a mild anesthesia, which means they will need some medication to help them sleep through the test.

ABR tests, when they are done with anesthesia, they are usually done through settings such as a same-day surgery center or in the OR, but in a setting where the anesthesia is monitored.

The test takes, if it is diagnostic meaning we will do a full complete test to assess for hearing loss, it will take about an hour to an hour and a half, but the entire appointment will usually take about two hours without anesthesia, and up to four if they need anesthesia due to recovery time and monitoring to ensure that all is well.

There are different types of auditory evoked potentials that we look at, and on this slide, this next slide here, excuse me, right here, it is the second bullet, the ABR auditory brainstem response, which is the most common.

Some of the others will be used for various other diagnostic purposes, but you probably will not come across those very often. [indiscernible] the auditory brainstem response tests that you will see most commonly.

This is one that is used in an automated fashion in newborn screening programs as well.

This slide here just gives an example of what we might look at. And an ABR report, we may referenced to various waves, and simply what that means is we look for certain waveforms or peaks that I will show you in a moment to occur at certain times that also correspond to different locations in the auditory system.

So the first few waves that we look at, 1 and 2, when those are present they will occur at the level of the auditory nerve.

There is a wave that we would call waiver 5 which occurs much further up in the auditory pathway in the brain, and we measure its presence, and we also measure how long it takes to go through.

Those are both indicators, presence and how long it takes, of the function of the auditory pathway.

This just gives you an example here as you look, we have got the outer ear, that sound goes in, stimulates the middle ear, stimulates the inner ear, and then the blue arrows show how it goes all the way up to the auditory cortex which is that area of the brain behind the skull and above the ear.

It is a very complex system, and we are really grateful to have the tools that we do that can help us look at these pathways.

And again, we look at how long it takes to go through, and we look at the various loudest levels that we would get the response that we are looking at.

This just gives you an example, you will never really need to look at waveforms or be able to interpret them, but various reports may referenced them, and I just wanted to show you one of those.

When I talked about waiver 5, that would be where this little arrow is in this largest drop down, and you can follow that down.

We start, the top wave is at 50 decibels or a normal conversational level.

We dropped to 30 decibels which is a quiet speech.

We dropped to 20 decibels, the waveform is still there and now about the level of a whisper.

And then we dropped clear down to 10, and we can see the remnants of a wave there, and this is a nice normal response that we would want to see.

And again here is another example of a normal response as we go from louder to soft.

Then this is one that would indicate a mild hearing loss, so we have the waveforms present at the louder levels in the first three waves, and we have lost it when we have gone down to 20 decibels or the level of a whisper. We don't have the waveform that can be repeated, so we have a mild hearing loss with this test result.

So why do we use ABR? One of the first reasons is because it is an objective test of the auditory pathways, so further along the system.

It is not affected by the patient's state or anesthesia. So the agents we would use to help a patient sleep through the test do not affect our ability to record the auditory brainstem response.

I will go ahead here, and let's move now to behavioral tests.

These behavioral tests really kind of pull it all together. We have gone from the outer ear to the middle ear to the inner ear, and we have looked at the auditory pathways, and now we are really looking at what a child does with response to sound.

These are tests where we assess a child's reaction to sound.

For us to react to sound, it needs to go through the whole auditory system, and then we interpret the sound at various levels.

For example we alert to detection, the presence or absence of sound, we can provide a deliberate response such as placing -- raising and/or placing a toy in a bucket when we hear the sound.

And we know that children with normal hearing who have the ability to participate in an otolaryngologic like this, they should be able to respond at a normal quiet level of about 20 DB.

So the behavioral tests that we use with young children, the first one is called the RA or visual reinforcement audiometer he.

What we're looking for there is we put a sound in -- and we condition the child, so we put a sound in, we get they had to turn, we reinforce that and we then continue to present the sounds, we get the response, it is conditioned so the now -- the child is doing it automatically with reinforcement, and then we go down to the quietest level we can get the response.

So for example we would have a child in a room, we would present a sound through a speaker, and then we might use a lighted toy that we would like up, and we would pair those two so we can condition the response.

Once that conditioned response was reliable, we would go down and find the quietest level we could observe that.

Condition play audiometry is for a child that is probably a little bit older and has more of an ability to provide a response.

In this case we will teach the child a game and the response that we want.

So the picture here, we have a child with a toy and they put it in a bucket every time they heard the sound, and we would train them to do that. Once they were responding reliably, we make the sound quieter, and then we go down to the quietest level that we get a reliable response.

So to summarize with these tests, we really move from the outside in, and we use all of the information from the various tests to build an entire picture of what is happening with a child's hearing so that we can describe the degree of hearing loss, the type of hearing loss that Jeff mentioned, so that we can also develop an appropriate treatment plan.

So I am going to turn the time back to Jeff now.

>> Thank you, Terry. I am going to skip through a few slides here in just a second.

There we go. Audiologists record a person's hearing ability on a chart called an audiogram which is shown here, and although an audiogram is not used to record a very young child's hearing evaluation results, it is useful for us as adults to understand the audiogram primarily because parents will soon begin seeing audiograms as the child gets a little bit older. This is a great way to look at the degree of hearing loss and the configuration of the hearing loss.

During a hearing test, the softest level that a particular sound can be heard is recorded for each ear on the audiogram, and this softest level is called a threshold.

During a hearing evaluation of the thresholds for different frequencies or pitches are measured, and frequency is measured in hertz, or it is sometimes abbreviated HZ.

The frequencies on the audiogram range from 125 hertz to 8000 hertz. So you can think of the portion of the audiogram like a piano keyboard.

The sounds on the left side of the low pitched bass quality sounds, and as he moved to the right they are higher pitched more on the treble end.

So although this is a much expanded scale from a piano.

But over on the right side, 8000 hertz, those are the higher pitches.

The intensity or the volume goes from soft to loud, soft at the top and loud at the bottom.

This is measured in decibels or DBs, so you will see that abbreviation, DB, sometimes.

The further you move down the audiogram, the louder the sound becomes. For example, a 10 decibels sound is softer than a whisper, while a 110 decibels sound at the bottom of the audiogram is as loud as an airplane.

In this particular audiogram, you see familiar sounds are plotted just for demonstration purposes, so it reveals what the frequency and loudness level of the sounds are.

For example, on the lower left-hand side you see a lawnmower. That is a very loud Lopez sound.

While the consonant S is a very soft high-pitched sound, so you see that over on the right side further toward the top.

Here is a variation of the audiogram, and the shaded area represents where the sounds of speech at a soft conversational level are.

If you look closely at this area, which is sometimes called a speech banana for obvious reasons, you will notice that the predominant energy of speech sounds okay in the loudness range from about 15 to 50 decibels or DB, and the pitch or frequency range is all across the board from about 250 hertz to 8000 hertz.

You will notice that vowels tend to be lower pitched, and louder than the consonants. There is more energy in the vowel sounds than there is in the consonants.

As you know, hearing is not an all or nothing situation. It has various degrees of hearing loss, just as vision does.

We're now going to take a look at the various degrees of hearing loss and how these are plotted on the audiogram.

Remember that the intensity or loudness level that a sound can just barely be heard is called the threshold, and the audiogram is set up so that if the threshold or the detection level of a sound is at a very soft level, it is marked at the top of the audiogram.

But if the sound has to be made very loud to be just barely detected, the threshold is marked at the bottom of the audiogram.

The red line across there on this audiogram indicates the average loudness level of typical conversation.

Normal hearing for children is in the range below 15 decibels, 15 DB. That corresponds to the pink band in this audiogram. In other words, for a person with normal hearing, button at any of those frequencies, any of those pitches, can be detected at very soft levels.

A person with normal hearing would be able to easily hear all of the louder sounds such as the sounds represented in the speech banana, and all of the other noises that we saw in the previous slide such as the lawnmower or the airplane.

Here we see the range of thresholds from minimal hearing loss. As you can see, some of the speech sounds in the speech banana such as the fffffffff and the thhhhh, the F and the TH, are no longer detectable, they are starting to drop out of the person's awareness.

So the child with hearing loss would not be able to the difference between the word fin like what a fish has and thin such as someone who is very slender based on the auditory signal alone.

So fin and thin, they would not be able to tell the difference even in the best listening environments because that is outside of their hearing ability.

All of the other speech sounds are being heard at a softer level even though they can be detected.

A mild hearing loss occurs when the sound of thresholds are between 25 and 40 DB.

You may think that mild is, well, mild, but look at how many speech sounds are not being heard. And the rest are coming through more like a whisper.

So mild really does have some significant impact on understanding what is being said, especially for a young child who is not get acquired language and cannot fill in the blanks like those of us with a long history of auditory access can do.

This next audiogram, we see the range of hearing thresholds for moderate hearing loss. Noticeably speech sounds for soft conversational speech are nearly inaccessible and that normal conversational levels would be perceived almost as a whisper.

Moderate, well, think about the impact that this degree of hearing loss would have been a child's access to day-to-day speech, or for that matter an adult's access to day-to-day speech. So moderate is not as minimal as what that term implies.

The orange bar on this audiogram shows that the threshold levels for a moderate to severe hearing loss is between 55 and 70 decibels. Most if not all of conversational speech could not be detected with this degree of hearing loss.

Most hearing losses are not flat. The thresholds at all of the different frequencies are typically not in the same decibel range.

Here we see an example of a common configuration of a hearing loss, that red dotted line.

In this example it is a mild to moderately severe sloping loss. So the hearing loss over on the low pitched side is mild. Over the higher pitched it is moderate to severe.

So some speech sounds are available to this person, but many are not. So there is a lack of clarity with many of the words, and we will hear some examples of this type of hearing loss in just a couple of minutes.

Once again, those of us who have a long history of accessing speech and language can fill in many of the gaps, but very young children do not have that advantage of that historical access to sounds.

So looking back just to the degree of hearing loss without taking into account different configurations, the blue area here indicates a severe hearing loss with thresholds of 7290 DB.

With this degree of hearing loss, typical conversation as well as many environmental sounds would essentially be inaudible.

And here we see these thresholds are in the profound level. Most sounds would not be -- could not be heard with a profound hearing loss.

Once again, there are many different and unique configurations of hearing loss. Each one makes some sounds and everyday conversations were difficult to access, and therefore makes understanding challenging.

In a minute Terry is going to explain about the different types of intervention options that are available, but first I would like us to listen to an example of some hearing loss.

The health ear institute several years ago modified a Flintstones cartoon to simulate different degrees of hearing loss.

As you watch this couple of minutes here, I guess even less than a minute, watch the small audiogram over on the right-hand corner. It is showing the degree of hearing loss, and the red line is, that is the degree of the hearing loss. The blue banana is the speech banana.

As we start, we are going to be with normal hearing when Barney is speaking, and it progresses to a severe hearing loss at the end when Wilma and Betty finish the cartoon segment.

So listen to it and see the progression of hearing loss.

>> 1, 2, 3, 4, 5, 6, 7.

>> You are on my apartment building on Granite Avenue. You only $300, get it up.

>> Take it easy, it is only a game.

>> Wilma, just like the big tycoons, I play to win. Barney, pay up or get out of the game

[indiscernible]

[Audio is getting fainter and fainter on the cartoon]

Okay, so you saw there the progression from normal to a hearing loss and how difficult it was at the end to understand what was being said.

You could pick up some from the expressions that were going on, but that was not sufficient. Just think a difficult it is to understand what is being said at the end, and we know the English language, we are able to add some things in to use some context. For a young child who is not acquired language, they find it much more difficult to make sense of these reduced or distorted sounds.

There are a couple of excellent online resources, and I will put these up so that you can write these down later if you want.

The first one is a YouTube animation of how the ear works. It is the auditory transduction by Brandon [indiscernible], and it is about seven minutes long and it shows how the whole ear works, if you need that for demonstration purposes.

A second link online is success for kids with hearing loss.com, and it has many links to hearing loss simulations, so I'm going to put these over here just in the notes field, the YouTube video and auditory transduction and success for kids with hearing loss.com for simulations.

I am going to turn it back to Terry now to talk about intervention and options.

>> Great, thank you, Jeff.

Great, so now we have screamed and we have assessed and we have diagnosed the children with hearing loss that we are working

with, and now we do that with the purpose that we can get to this point, that we can provide treatment and intervention.

It is really important to note that these timelines that we talked about with the joint committee on infant hearing are just as important or more so for intervention as they are with the other work that we're doing.

Early intervention includes the communication modalities that we will be working with. So that would be whether we are going to maximize auditory function and verbal and spoken language, whether we are using Sai-Ling which or cued speech or a combination or total communication, or the various communication strategies available to families, as well as emotional, [indiscernible] support.

As audiologists we work with and refer to early interventionists and specialists in Deaf education and education of hard of hearing children.

We work with speech therapist that specializing hearing impairment, and again with educators for the death.

We also work in the areas of medical and nonsurgical intervention.

We would make referrals for medical intervention that can include surgical treatment.

For example if hearing loss is conductive in nature in the middle ear space it can be something such as a tumor in that space that can be surgically removed and hearing can be hopefully restored.

It could be treatment for chronic middle ear disorder. We also will assess, prescribed, and fit hearing aids.

We have parts of the cochlear implant teams, we help make the candidacy assessments, and we program the implants and work with patients, and then we also work with FM systems and other tools all designed to help maximize the auditory potential that the child has.

Communication options are really important. And this slide is blank, and it is really just to illustrate that our families get to write their story and their choices here. It is really open to them for family choice.

Family choices for intervention can include all of those options that I talked about before, whether they want to go ahead with hearing aids, whether they are interested in cochlear implants, and what can indication strategies do they want.

It is really for them to write their story here. We don't tell them, but we educate, we try to provide information, we refer to experts in the various communication approaches, and we help support the family and their choices.

With amplification, again referring back to the joint commission on infant hearing that we want to fit as soon as possible in children with permanent hearing loss, they need to be fit as soon as they can so we can get that optimal stimulation.

With hearing aids, just really quickly, our main point here is there is a lot of different options with hearing aids, and they have wide range is a fitting ability.

It is possible to the take a message for us today, we want everyone to know it is possible to proceed with amplification as soon as a diagnosis of hearing loss is made.

Knowing the benefits of early amplification, we encourage parents to do this as soon as possible. We would consider this the first step in rehabilitation.

Hearing aids have various parts, and we work with those, we try to ensure that they are functioning appropriately, and we fit that individual child's needs.

Like I mentioned a little earlier, we help with cochlear implantation and candidacy. This gives you an example of what the current candidacy requirements are.

During their exploration, parents may ask if their baby is a candidate for a cochlear implant, and this shows the current criteria.

You can also advise physicians to confer with the cochlear implant team if they have any uncertainty about a child's candidacy.

This just gives you an idea of what the implant entails. There is a surgically implanted piece behind the skull that is threaded down into the inner ear, and it transmits sound to a

processor. Then the child is able to interpret that stimulation at sound.

FM systems are just another tool that we use to help improve the signal to noise ratio making the sound strong enough over background noise that they can hear it.

It's another way to help maximize their auditory potential.

As an audiologist, we want to be a member of the early intervention team. And we have put some questions up here that you can help ask, that you can ask in order to facilitate inclusion of the audiologist as part of the team.

We can provide the information on what they can hear with and without amplification, what is the best distance, communication distance for the child with whatever tools that they have.

We can provide training and troubleshooting amplification devices and other supportive strategies.

This gives you an example of some of the types of things we can help with in order to maximize their auditory environment.

This is an example of the distance. So when Jeff talked about the audibility of various sounds in regards to the speech banana, distance is also important.

We have a saying that says come closer to me by 6 DB, but really what that means is that every time we decrease or half the distance that we are from a child, just that decrease in distance increases the auditory sound by six decibels.

So distance ends up being very important, and we can help provide training and education for early interventionists and families and how to maximize those auditory tools.

We can help with visual environmental things to highlight the visual environment, and this gives you an example of such things such as positioning and lighting, directing to auditory language information, and positioning.

And then we will continue to monitor and manage their hearing loss. We want to ensure that we are staying on top of that as hearing can change and get were sometimes over time.

We want to plan for future needs, we want to ensure for the hearing aids, for example, fit and have flexibility if the hearing changes so the family were not have to buy a new set after a year or two if that child's hearing was to change.

We monitor the hearing aid and implant function, and then we provide educational input and consultation in whatever manner would be helpful in helping that child's intervention and treatment plan.

Just some suggestions on how to work collaboratively with audiologists. And I would say just being a member of the children's teams and really enjoy the invitation to participate, and keep asking the questions because we really want to be able to provide whatever we can to help the success of these children.

The take home message for us today and to review our presentation is that hearing loss is described by the parts of ears protected, and it can be temporary or permanent.

An audiogram is how we craft hearing sensitivity, and as Jeff went over that, it lets us know loudness and pitch differences.

And even mild and moderate hearing loss significantly affects the ability to hear speech which affects speech and language development.

Children referred from screening can and should be assessed as soon as possible. We can use the battery of tests that we talked about right away, especially those objective tests.

Family choices for treatment and intervention include hearing aids, cochlear implants, and a variety of early intervention strategies that are available.

If you have any questions about hearing, be sure and ask us.

>> Terry, I can go ahead and finish up here. Terry and I want to thank all of you for joining us for the webinar this afternoon. And if you have any questions, we don't have time for any questions and answers here as part of this, but my email is [indiscernible], so it is [indiscernible], we would be glad to answer any questions that you have that this webinar has stimulated for you.

Sorry for going a bit over, we went about 10 minutes over, Terry and I just had way too much information for you.

So thank you all very much.

>> Thank you Jeff and Terry for today's webinar. Everyone, this will be posted at InfinityHearing.org within the next week, so if you want to review it again or share it with anybody else, we direct you to InfinityHearing.org.

Thank you, everyone.