Fit or Fiction: Why and How Every Audiologist Can Incorporate Hearing Protector Fit Testing in Their Practice

Presenters: Christa Themann, MA, CCC-A, Wei Gong, MS, CIH

At this time, it's my pleasure to introduce our presenters. Today we have two presenters, Christa Themann, who is a research audiologist at the National Institute for Occupational Safety and Health, where she has worked for over 30 years, and Wei Gong, a certified industrial hygienist and certified occupational hearing conservationist, also with the National Institute for Occupational Safety and Health (NIOSH). And I invite you to read more about our presenters at our website. At this time, I'll turn the microphone over to our presenters. Thank you, Carolyn, for that warm introduction and hello everyone.

And thank you for joining us today for our webinar Wei and I are very happy to be able to talk to you about hearing protector fit testing today. It's something we're very passionate about and we think it should be an important aspect of audiology practice, and we're hoping to convince you the same.

Here are our disclosures. They're also posted on the Audiology Online course page. And here are some limitations and risks that are associated with taking audiology Online courses. I just want to kind of draw your attention to the first one, which mentions that you should always be that regulations, if you're doing hearing protective testing, any kind of a regulatory context, that regulations vary from area to area. So we'll talk very generally and very briefly about some federal guidelines, but you should always make sure that you know what the regulatory context is where you are working.

Here are our learning outcomes, which we assume that you read, and that's what inspired you to join our course today. I think I might have blazed through our disclaimer slide. Let me just real quickly just pop in and tell you that Wei and I are both federal employees, and as such we want you to be aware that everything that we say today are our opinions and our opinions alone. They don't necessarily reflect the policies or the opinions of the National Institute for Occupational Safety and Health or the Centers for Disease Control and Prevention. And we also want to mention that throughout the webinar today, there's periodically going to be photographs of some audiometric equipment or some hearing protection devices.

And similarly, please don't interpret that as any sort of endorsement by CDC or niosh. They're just examples. So here's an outline of what we want to talk about today before we actually jump into fit testing. We want to spend a few minutes setting the stage, so to speak, by talking about prevention as a key component of audiology practice. I think that our profession has historically focused almost exclusively on helping those who already have a hearing loss, which of course is fantastic.

It's what drew me to the profession. I'm sure it's what inspired many of you to want to be audiologists as well. But I think that we haven't as a profession put as much emphasis on prevention as some other health professions. I think we've tended to think about hearing loss prevention as something that's done just by a

few audiologists who happen to work in occupational hearing loss prevention. But I think that every audiologist has a role to play in preventing hearing loss.

And we're going to start our webinar by kind of making a case for that. Then I will turn it over to Wei, who will introduce us to hearing protector fit testing and why it should be a key component of hearing loss prevention. She will talk about how hearing protectors are evaluated and show us some of the evidence base that supports hearing protector fit testing as a means of preventing hearing loss. And then we'll discuss the two main approaches to conducting hearing protector fit testing, describe how we can incorporate it in clinical practice, and then finally, we have some guidelines for you in terms of recommending hearing protectors to your patients or clients.

Okay, we're going to start off today with a poll. Please tell us what you think is the most common cause of preventable adult onset hearing loss. Do you think it's noise exposure? Do you think it's disease? Perhaps it could be traumatic injury or ototoxicity?

What do you see is what would you consider the most common cause of preventable adult onset hearing loss?

Give you a few seconds here to weigh in and then we'll go ahead and take a look at the results of that poll and see what you thought.

Fantastic. The vast majority of you, 97% saw noise induced hearing loss as the most common cause of preventable adult onset hearing loss. And then there were a few votes for ototoxicity, which also can sometimes be prevented. So thank you so much for sharing your opinions there. And we completely, completely agree.

Noise exposure is a major cause of adult hearing loss and noise induced hearing loss is almost always 100% preventable. Data show that 22 million US workers are exposed to noise annually on the job and 58% of workers, 58% of self reported hearing difficulty among workers can be attributed to their workplace noise exposure. So this is a real shame because since hearing loss from noises preventable, it's kind of a shame that there's still this much hearing loss that's resulting from noise exposure at work. Now I'm sure all of us can think of noisy jobs across the industries right off the top of our head, we think automatically of manufacturing, construction, mining, but actually there are noise exposed workers in just about every industry. And hearing risks exist pretty much across the board.

Unfortunately, the problem is not getting any better. These data are from the NIOSH Occupational Hearing Loss Surveillance Program, which collects de identified audiometric test results from companies who test noise exposed workers because of regulatory requirements. So these are audiograms collected as part of occupational hearing loss prevention programs. And this chart is

showing the prevalence of hearing loss among workers overall and in various industry sectors over the 30 years between 1981 and 2010. And you can see that for the most part, the prevalence of hearing loss hasn't changed.

In fact, among noise exposed tested workers, the overall prevalence of hearing trouble decreased less than 1% over the past over those 30 years. And noise exposure has been regulated in the United States since 1970. And we really do know how to prevent hearing loss or noise exposure, but unfortunately, it just isn't happening.

And I also want to point out that it's not just workers. These are data from the National Health and Nutrition Examination Survey, or nhanes, which has been conducting audiometric testing on a nationally representative sample of U.S. adults. And this chart shows the prevalence of both unilateral and bilateral audiometric notches in men and women with and without a history of workplace noise exposure. You can see from the bars that persons who were exposed to loud noise at work were twice as likely to have a notch than those who weren't. And that stands to reason, that's what you would expect.

But if you look at just those adults whose threshold showed an audiometric notch, 20% of them had no occupational noise exposure history at all. They reported no history of noise exposure at work. So this amounts to an estimated 21 million adults with audiometric notches on their audiograms and no history of workplace noise exposure.

Loud sounds, therefore, are not just at work. An estimated 21 million adults in the United States likely have hearing damage from loud sound sources that occurred either in their home or in their communities. So these kinds of noises are really very common and include things like attending concerts or sporting events, using lawn equipment or power tools, hobbies that involve recreational vehicles, hunting and shooting, or prolonged listening to loud music.

And it's also not just adults who are at risk. The World Health organization estimates that 1.1 billion young people are at risk from hearing loss that's totally preventable, primarily due to listening to loud music or music through personal listening devices. So this is a huge number of individuals at risk for hearing loss, which is totally preventable. And audiologists really are the best professionals who are in a position to step in and do something about it.

Now, we all know that hearing damage accumulates over time. So looking again at the NHANES data, we can see that the presence of audiometric notches increases with age, ranging from 19% among those who are in their 20s and going all the way up to almost 30% among individuals in their 40s. Then we start to see the prevalence of noise notches decline, and that's due to the increasing effect of aging later in life that masks starts to mask that audiometric notch. The problem of noise induced hearing loss occurs across all age groups and becomes more and more prevalent with increasing age.

And unfortunately, many people with noise induced hearing loss just don't recognize it, which I'm sure comes as no surprise to the folks in this audience. Again, looking at the NHANES data, nearly 20% of persons who had a notch on their audiogram reported that they felt their hearing was excellent or good. So a large number of people with clinically evident noise damage potentially are either unaware of or ignoring the effects of of noise on their hearing. So one key approach to preventing noise damage is, of course, to use hearing protection. But the same study, the NHANES data, show that 70% of persons who report being exposed to loud noise in the past 12 months had seldom or never used hearing protection when they were exposed to loud noise.

So we have a long way to go in getting the message of hearing loss prevention out to folks.

And again, I'm sure I don't need to belabor this point with this audience, but hearing loss has many consequences, which range from obvious problems with communication to recent evidence that shows associations with cognitive decline, Impacts on education and employment, Impacts on social interaction, Emotional well being. And hearing loss also comes with a huge price tag. The World Health Organization estimates that the annual costs of hearing loss are on the order of $980 billion across the globe. So even so, making a small dent preventing any of these hearing losses has the potential to really save on this huge cost to society.

Hearing loss is definitely a growing epidemic. The World Health Organization estimates that more than 360 million individuals worldwide live with a disabling hearing loss. And as you can see from the chart, this number is projected to grow over time. So obviously there are some hearing losses that we cannot prevent. But as we've seen, we could make a huge dent in the hearing loss epidemic by preventing the hearing losses that are due to noise exposure and that's where we think hearing protector fit testing fits in.

So how can we control this epidemic? There's some obvious ways to reduce noise induced hearing loss, obviously by avoiding loud noise sources, lowering the volume on those sources, increasing the distance between the listener and the source, shortening the amount of listening time and the use of hearing protection. But hearing protection needs to fit well in order to effectively reduce the noise exposure. And that is where fit testing comes in. So hearing protector fit testing refers to any procedure that's designed to measure the actual amount of a sound reduction that an individual user receives from a particular hearing protector.

So it's a quantitative estimate of the attenuation that a hearing protector is giving to a particular user of that hearing protector.

And as we kind of wrap up this making of our case for hearing loss prevention is an essential part of audiology practice and start moving more into hearing

protector fit testing specifically. I just want to point out that the other ways of reducing noise exposure that we just mentioned, avoiding loud noise sources or lowering the volume, that sort of thing, those are actually more effective at preventing noise induced hearing loss than simply the use of hearing protection. So this chart is taken from occupational health and safety science and it shows the various means of preventing the results of certain hazards, starting with the most effective means at the top of the triangle and going down, as you go down to the least effective means. So you can see at the top of the chart, eliminating the exposure altogether. Obviously, the most effective means of preventing the results of that exposure and the use of personal protective equipment, which is where hearing protectors fall in, is actually the least effective method.

And don't misunderstand, hearing protection can be very effective at preventing hearing loss. And we're big fans of hearing protection. But when you use hearing protection to prevent noise induced hearing loss, you're relying on every individual user to wear the hearing protection whenever they're exposed to noise, to wear it properly. And so you're sort of preventing noise induced hearing loss at an individual level as opposed to a more global level, which is, you know, what you would see if you just eliminated the noise altogether. But fit testing, as we are about to see, is the way to ensure that folks are properly fit.

And then we just need to help our patients and clients understand that they need to use hearing protection consistently whenever they're exposed to noise.

And unfortunately, folks don't consistently use hearing protection devices. These again, are data from, these are data from the National Health Interview Survey, actually, which shows how often people who were exposed to the various types of noise in the past 12 months actually used hearing protection when they were exposed to those noise sources. The orange bars at the top are folks who always use hearing protection. And then as you go down to the blue bar at the bottom those are folks who never used hearing protection. So if you look at the bar chart in the lower right corner of the graph, those are folks who were exposed to noise non occupationally so noise outside of work.

You can see that over 60% of those individuals reported that they never used a hearing protector when they were exposed to noise. So this is something that I think we as audiologists should really work hard to improve. So now I'm going to turn the floor over to Wei to give us some background on how hearing protectors are measured and why hearing protector fit testing is so important. Yeah, I think before we talking about fit testing and there is a very, there is a very important like terms we call it noise reduction rating or NRR for the hearing protectors. Like you guys can see in this slide this is labeled with the NRR.

It is required by law have to specify in every each of the HPD served in the U.S. so how did this NRR come out? Actually it's according to the EPA, the Environmental Protection Agency’s regulations on how to do it. So actually it's like it's come out like they specified. If we want to calculate the NRR, it has to be

tested in a laboratory environment with 10 subjects and those subjects they do nothing, they just provide their ears. So the scientists in the lab, they know the HPD very well, they can fit those HPD to those subjects very well.

Then they tested the result from those fittings. So then we can see the NRR is an average value from a group of subjects with expert fittings with three repeated fittings. Actually it clearly shows it's just the best optimal fits for those result confirm. I'm not sure if I can explain this NRR very well. So that comes from another question.

Do you think that the NRR tells you how much noise reduction a person is getting? True or false? Not sure. Please vote, and I want to see the results. Very well, Let me see how many people getting for the result.

So let's see. I cannot see the results yet. Yes, we'll go ahead and close the poll and see what people thought. Okay.

Oh, so true is 31%, false is 54%, and not sure is 14%. So I think basically I did a good job because majority of them still think it's false because actually noise, the noise reduction rating comes from the lab settings and it's just for the experts fittings, it's not fitting by the workers. It definitely cannot tell you how much noise reduction a person is getting. So as you may already know, the field attenuation is generally lower than the noise reduction reading shooting in their labels. There is a notable studies like as many other researchers have already shown that for NIOSH we'll always plot our notable study we conducted in 1977 and 1981.

These studies involves about like 400 workers at the 15 different individual plants they tested like eight types of earplugs each workers tested five times with hearing protections as they worn in the fit in that factories. That means they fit their earplugs by themselves. So when we look at the results shows in this chart, it clearly shows the workers' results represented here in the red area. They are basically far below the blue area. That's the laboratory result which we can calculate the NRR, and another finding we found that we have a big red area means that the data from the workers has more variability compared to the data from the labels.

And this discrepancy has been verified over and over in nearly every studies that have investigated it. Look at this chart. This bar chart shows a result from the number of NIOSH studies over the years. The blue bars represent the NRR for different hearing protectors and the orange bars represent workers at simply put, clearly those workers could not fit their earplugs as good as those laboratory scientists do. Those data are what has led to the various de-rating schemes here in the US and elsewhere.

So first I really want to highlight that we have a lot of different de-rating approaches have been adopted by a number of countries. If we look at the NIOSH as we found and before January 25, right. We just updated the policy.

Before that we said we recommended a de-rating factor of 50% for earmuffs and 75% for foam earplugs. And for the other plugs is 30%.

But for the OSHA you can see it's totally like different from ours. They just use 50%. If you look at Canada, they have different criteria. They use 97% for the earmuffs and 50% for earplugs. They also use the different convert factors between the A weighted noise and C weighted noise.

And in China is another different story is before that they use 50, 60% of that SNR. What's SNR? It's actually another single number rating for the earplugs it's different metric for to show how the potential performance on the ear plug or ear muff can get before that's. That's the China provided that like before the January 2021. Then later they dropped that they just prefer you to choose those correct the earplugs according to what the noise level of exposure is.

So because that when we estimate the attenuation from a specific specific earplug or ear muf the result can dramatically different across countries. For example, if we look at those. If I look at the chart 3M 1270 is a pre-molded earplug with an NRR value of 25 dB. And if we applied different derating schemes that the estimated attenuation would range from 0 to 15 decibel. If your work wears the same type of ear plug, can you say that work received different protections from the earplugs only because the worker is in the different countries?

It does not make any sense. Correct. So there is another way we are talking about the problem of de-rating. If you There is a study, it was conducted by NAS a long time years ago and we tested 192 workers who all used the same earplugs. The NRR value of this earplug was 27.

Then look at all the all those attenuation gate from each users. It's just literally ranged from virtually 0 to 38 decibel. So the the de-rating system does not represent the variability in attenuation received by individual workers. So why it. Why does it happen?

Because I think there is a lot of factors which can contribute to the variability in noise attenuation from hearing protectors, such as the fact that each and every individual has different sized ear canals and the head size. And not everybody has equal knowledge about the proper fitting technique for the HPDs. And they also don't know some people. Some people never realize that noise hazards can can damage their hearing. And once one important things I want to point out is like.

Like once you wear your earplugs if you don't feel comfortable like ill-fitting shoes. I don't think you can wear the earplugs like consistently and correctly. So the solution is, as Christa already mentioned,, if you want to know exactly how much protection workers can receive from their earplugs or earmuffs, the only solution is the personal attenuation rating (PAR) that we can obtain from fit

testing systems. So if you look at the grandma, who used her fingers to insert her earplugs.

And she got like 23 decibels attenuation. But grandpa did the same thing, but she was. He was a little bit worse than the grandma did. He only got like 18 and 19 decibels.

So this slide summarized the big differences between the NRR and pa. As I said before, the NRR is the laboratory test is obtained from the group of the subjects. It's average value. And the most important the data is from the experimental fit. That's from the scientists. They know how to fit the earplugs very well.

But for the PAR, it's the field test is for the individual measurement is fit by those users by themselves. So that's a totally different two terms. Now when we're talking about the path, we really want to find out what's the ideal PAR. We should be in these cases. I would say the ideal PAR would mean the user is neither overprotected nor underprotected.

The protected noise exposure should range between 70 to 85 decibel. There is another way we can explain what's over and under protection. If we look at the left photograph. You can see for this graph. This camera lens looks like a camera lens let a lot too much light into the.

Into the photo. That means it was overexposed. Then under these situations, if we applied this to that earplug, it looks like the workers or users cannot wear their earplugs well. So they got too much noise into their ears.

That means they have under protected. But if we look at the other side, the right side pictures looks like you wear a sunglasses blocked too much light. Then the figure the graph does not looks like that clear. So in this situation sounds like you use the earplugs and it's too much. You block too much noise.

And it's especially. I think it will be dangerous because for those workers you cannot hear critical sounds, especially for those workers with hearing loss. The only way we want the probably protected as the middle photo shows.

That means at this point those protected exposure levels should land between 70 and 85 dB.

So one concerns like when we go to the workplaces. When we ask those workers why don't you wear your earplugs? And they always concerned about. No, we cannot wear earplugs. Because once we wear them we cannot hear any sounds I want to hear.

But actually for the earplugs and. Or the earmuffs. If you wear them correctly. For those with normal hearings. And they can help them to.

To. To hear better. Because they just reduce the distortion from the surrounding noise and those others those are really feedbacks from the real workers or the real users once they experience the fit testing and they know how a well fitted HPDS works for them and they just come out oh, I know these feelings and I know now I can hear very clearly all those understandings for Those well fitted HPDs really help them to drop to that the previous concerns oh, I cannot hear anything or something like that and help them to wear them wear earplugs or earmuffs correctly and more use. I wear them more often and more consistently. It's a very good approach I would say for the fit testings help them to understanding correct.

Wearing hearing protection is important to help them to protect their hearing. So come to this point I would like to say even now we know fit testing is the best solution to understand how much exactly the attenuation those users can get from their ear plugs earmuffs. But it's definitely, definitely a long journey to developing fit testing systems. The first fit testing systems developed by niosh is in 1977. And look at that the image here.

They did use a significant amount of physical equipment to do the test. So clearly it's not easy to put them into the workplaces to do the daily use to check every workers how much attention they can get from their earplugs until 40 years later, with modern computer technology, we now have laptops and tablets and those advantage technology helped to make a smaller fit testing systems. So usually right now the fit testing systems on the market only require a laptop or computer with a sound card and a large-cup headset. And usually they use a switch or a computer mouse and you can just respond to the test sounds. So right now currently in the market a number of the fit testing systems are available.

This helps with implementing fit testing anywhere you want to measure attenuation for users. So we are talking about fit testing systems Pretty soon Christa will do that. But before that I don't want to drop my time so I will talk about some studies we conducted over the past years because I think for all those studies just highlights how important the testing is and why do we should do that. So the first case study was conducted at an auto parts facility. Despite the manager implementing the various noise controls the average noise exposure levels remained around 7087 decibel.

It's not very high. But those workers years and years always has new cases we hearing loss come out. So as A result, workers were required to wear a specific type of pre-molded earplugs with an NRR of 25 dB over their eight hour work shift. When we do the study, we literally observed those workers really did wear their earplugs over their entire work shift. It's amazing work, but it does not help.

We still have the new cases of hearing loss come out. Then we did a fit testing for those workers and the result come out for the in total 385 workers, 30% of them. That means like approximately 147 workers were not getting any protection from their earplugs. They already wear them for six months for six

years and nobody getting any protections from their ear plugs. They wear them for eight hour work shift.

It does not help. So sorry. So workers reported that yes, managers gave them hearing protectors whenever they needed them and they only provide them the material. But they did not tell them how to use it. They don't know how to wear them correctly.

So it clearly shows like. Just handing out hearing protectors does not ensure sufficient noise reduction. Here is another case studies conducted conducted like at the site along the Gulf of Mexico. Inspectors had to ride in a helicopter out to the west reach the noise exposure which could be as high as 100 decibel and might last for up to two hours. So therefore we set a target attenuation of 25 dB.

Then you can see the horizontal lines in this chart is 25 decibel line. So initial fit testing showed that only about half of the inspectors got 25 dB or more from the earplugs. You can see those blue dots above those horizontal 25 lines. Only half of them achieved that like 25 decibel or more. But half of them did not.

So we. We did the. We actually first we tried to tell them how to correctly wear those earplugs. Then we do the fit testing again. But if some of them could still could not achieve like 25 decibel then we will give them another type of the earplugs.

Ear muffs. Earplug, Sorry, only earplugs. Then until we find the one they can provide efficient protections. Then at the end of all those tests and applied all those individualized instructions. In the end, 92 of the inspectors were getting at least a 25 decibel of attenuation as shown by the blue dots.

We also published a Cochrane review two years ago. Then this review highlights that like if we highlight that after workers received the extensive training such as individualized training in correct method of wearing earplugs and self fit under supervision of a trainer. There is an average increase of 8 decibel in the personal attenuation in the personal attenuation rating. So you may have no idea about 8 decibel how meaningful for us because we know that literally only a 3 dB reduction effectively halves the noise energy. So therefore an increase of 8 dB in PAR indicates a significant enhancement in protection against occupational noise exposure.

So as previously mentioned, early studies were based on current fit testing technologies that put personal attenuation levels will only represent the attenuation received at the single point in the test. So to address these problems, NIOSH or yes, the NIOSH conducted several studies to determine whether the attenuation provided by earplugs change over work shift. So these figures come from a study conducted at a brewery facility in Colorado over a span of three years. Each year around 20 workers were tested using one type of foam earplug and one type of pre-molded earplug. Fit testing was conducted before the work

shift to ensure that each worker achieved a minimal attenuation of 15 decibels from their earplugs.

The worker was then tested again after their two hour work shift during which they were not allowed to touch their earplugs. So this chart summarized the. The differences between the two. Between the.

Sorry. Between the attenuation we tested before the shift and after two hour shift. You can see all, pretty much all the types of earplugs showed a slight drop in attenuation but it's almost within like 2 decibels. And if we look at the. So if we look at the data from each individuals actually like for 90% of the individuals after a two-hour work shift they still can maintain their minimum 15 decibels attenuation.

These findings suggest that most workers still received adequate attenuation while performing their work duties during the two hour period providing they wear their earplugs correctly. So this is the last study I want to present here because it's a very important studies. It's a longitudinal study in which we tested workers two or three times. We visited twice. On the first visit, we tested them with the earplugs worn just however they normally wore them. Then we trained them on how to wear their earplugs correctly.

So you can see the bottom blue line represents the mean baseline PAR before training, which was about 7 dB. Then the up Red line shows the mean post-training PAR which was about 18 dB. The difference between post- and pre-training PAR is 11 dB, meaning once they get the individualized training they improved their PAR by 11 dB, which is remarkable. Then in six months later we visited again. This time we just tested them fit tested them directly.

We didn't apply any training for them. Then we can see the mean PAR represented by the yellow line in this figure is about 14 dB. So if we compare this data with the post training red line the mean PAR was 4 dB less. But if we compare it with the baseline part before the training six months ago then the six-month follow-up showed a 7 dB improvement in the mean PAR. These improvements demonstrate that training is effective and can be maintained over time.

In workplaces, when workers don't know how to correctly choose hearing protectors, they always rely on the NRR values. But as we have demonstrated in this chart and other slides, Like this chart shows that it's clearly demonstrated that her HPDs with high NRR values may not always provide higher levels of attenuation particularly look at this chart for the foam earplugs because as we all know foam earplugs are usually harder to fit if you don't know the correct way to fit them. So once again want to say that solely relying on the labeled NRR values when selecting an HPD may not ensure efficient noise attenuation.

So I would yeah this comes out our third polling questions right? Yes. Have you ever heard hearing protector fit testing before this webinar? Please give us honest answer because we do have the data to compare with.

Okay, is it your turn? Thanks, Wei. So we can launch this poll and just find out how many people were aware of hearing protector fit testing before for this webinar. That would help us to know how prevalent this knowledge is among clinical audiologists and kind of help us know how much where we should invest our efforts in trying to spread the word about hearing protector fit testing. So we'll go ahead and close that poll and see what we have.

What the results show it's about 50 50. So 47% of folks were aware of hearing protector fit testing before the webinar and 53% were not. So we're so glad that everybody came and I'm going to talk now about how we can implement hearing protector fit testing in clinical practice.

Wait, can you move the slide before? Sorry, it's not working.

That's okay, so let me talk real quick. First, I'm going to describe there's basically two approaches to doing a hearing protector fit test. You can use what we call a subjective method or a psychophysical testing method. And basically when you're doing this approach, you're getting some measure of hearing ability from the person being tested with the hearing protector in place and without the hearing protector in place. And then you just compare those two sets of results and the difference tells you how much noise reduction the hearing protector is providing.

So pretty straightforward, some kind of a hearing testing method with a protector in place, without the protector in place and look at the differences. And currently there are two approaches that make use of this kind of subjective method. One is called real ear attenuation at threshold, which is kind of fancy hearing protector lingo for saying do a hearing test, a regular threshold test, with and without hearing protectors, and then a loudness balance procedure. Let me just explain real ear attenuation at threshold first. Basically, you're just doing a hearing test using narrowband noise signals.

We always use narrowband noise signals when we're doing hearing protector fit testing. And you just do a regular hearing test without any hearing protection in place. And that gives you un occluded or ears open thresholds. And then you have the person being tested put the hearing protector on themselves. And then you repeat that hearing test and you get a set of occluded thresholds.

And then the differences at each of those octave at each of those frequencies tells you how much noise reduction the person was able to get from the hearing protector. The other way to do it is using a loudness balance procedure. And let me kind of walk you through this step by step because it's a little bit less intuitive. So basically, you start with a person wearing no hearing protection at all in either

ear, and you place signals going back and forth through the headphones in each ear and you have the person adjust by themselves the level of the sound in each ear until it sounds equal to the person being tested. So in this example we're going to say that they kind of equalize there at around 30 decibels.

Then you have the person put the earplug in one ear. So we'll say in this example that they put the earplug in their left ear and they repeat the balance procedure. And in this example, the person had to turn the sound up in their left ear by 20 decibels in order to make it sound equal with the right ear again. And so we say that the ear plug is providing 20 decibels of attenuation in the left ear. Then you have the person put the earplug in their right ear and they adjust again.

And now they have to turn the right ear, in this example, up by 15 dB in order to be equal to the sound on the left. So in this example, using loudness balancing, we can tell that the person was getting 20 decibels of noise reduction in their left ear and 15 decibels in their right ear.

With everything else, there are pros and cons to each of these methods. Psychophysical or subjective testing usually takes a bit longer than the other approach, which I'll tell you about in a minute because we're waiting on responses from the person being tested. So depending on how many frequencies you're testing, it can take anywhere from 1 to 10 minutes. In general, these approaches can only test earplugs and not earmuffs. And I'm seeing a question in the Q and A about whether we're testing in sound field or with TDH 39 earphones.

So the dedicated fit test systems that are on the market are not using a sound field. They're using not TDH earphones, but like a large volume ear cup, you need to have a headphone that has enough space to under the headphone that it won't touch the hearing protector. So even something like a Sennheiser HD 200, which is like a large volume hearing earphone used for high frequency audiometry in the United States, even that doesn't have enough volume. So these are specially designed headphones that fit over the hearing protector without touching them. But we're going to get in a minute.

You can do this in a clinical audiometry setting using sound field. So we'll get to that in just a second.

So, yeah, so basically with a subjective system, one of the disadvantages is that when you use these dedicated fit test systems that are on the market, this kind of procedure can't be used to test ear muffs. You can. Some of these systems will give you end results for individual ears. So they'll test each ear individually. Some of them only test both ears together.

One disadvantage to the loudness balance approach is that it's kind of an unfamiliar task. A lot of people have had their hearing tested, at least at some point, and are used to listening for quiet sounds and letting us know when they

hear them. Loudness balancing is there's a little bit more of a learning curve on that because it's not as familiar to folks. And also with both of these approaches, you can run into ceiling effects. So if you have someone who has a pretty significant hearing loss at a particular frequency, you might not be able to make the sound loud enough in the occluded condition to truly figure out how much noise reduction they're getting.

It might, it might result in an underestimate. So the other approach to hearing protector fit testing is what we call physical. A physical approach or an objective approach. It's also called microphone in real ear. So basically it uses these kinds of systems, use a dual microphone system to measure noise simultaneously underneath the hearing protector and outside the hearing protector.

You can kind of see that in the little circular insets in this drawing that there's a microphone underneath the hearing protector. There's another one just outside the hearing protector. Then there's a speaker that blasts a particular noise briefly. And those microphones measure the noise occluded and unoccluded. And you can use those, the differences in those measurements to calculate the part pros and cons to this approach at all.

The main advantage is that this approach is very fast. Once the person is set up, it only takes about 10 seconds to run the test. These systems can test both earplugs and earmuffs, but the downside is that they require specially probe hearing protectors. So you can see in the lower picture on this slide that these are standard hearing protectors, standard earplugs that workers use all the time that are available, you know, for, for anyone to purchase. But in order to do the fit test, the company puts a special probe through the center of the earplug so that you can slide the, the microphone device into that probe and measure the sound underneath the earplug.

So that's the, the main disadvantage to this kind of a system. It tests across all frequencies. It's usually like a broad band, a white noise signal. So simultaneously it gets your data across the full frequency range. It tests each ear individually.

Another nice thing about this is that it's unaffected by moderate levels of background noise and there aren't any ceiling effects because we're not asking for any response from the person being tested. If you were going to buy a particular, if you were going to buy a dedicated fit test system, these are some issues that you might want to think about. But what I want to focus on for the next few minutes is how you can do this using, using equipment that is found in most audiology clinics. So as audiologists, we really don't even need special equipment to do this. We can do this with equipment that we already have on hand as the person suggested when they were asking the question about sound field versus headphones.

We can do this just by doing sound field audiometry with narrowband noise signals and a sound booth. You can have the person sit in the sound booth, do a sound field audiogram with no hearing protectors in place. Get another audiogram with the hearing protectors in place and it can be earplugs or ear muffs. You calculate the threshold differences and you've got a sense of how much noise reduction they're getting. This is a bilateral measure.

When you do this in sound field, obviously you're testing both ears at the same time. So sometimes you'll get a very poor result. But one ear fit very well, but the other ear is not fit as well. And so it can take some kind of trial and error to figure out which hearing protector is being well fit and which one might need some extra work. I also want to point out that there is actually a CPT code for doing hearing protector fit testing.

It's right there on the screen. So there is a billing code that you can use if you do hear protector fit testing in the clinic. You can also do hearing protector fit testing using the physical approach, using a hearing aid verification system. So this is the kind of system that people do use to use real ear measures on when someone is being fit with a hearing aid. It uses just a broadband noise signal, a pink noise signal.

You put the probe microphone in the ear just like you would do if you were doing a hearing aid check. And you would first get a real ear unoccluded response. That's the upper curve on the photograph in the slide. Then you would have the person put the hearing protectors in place and then you would run the real ear aided response.

So normally if you were doing this with a hearing aid, you would expect the second curve to be higher than the un occluded response because the hearing aid is providing some gain. In this case, you're going to get negative real ear aided responses because the hearing protectors are blocking the noise. So your real ear insertion gain is really going to be a real ear insertion loss. But you can use this system to do this kind of test. There is an issue of Seminars in Hearing.

It's shown on the reference list and there's a link, noted at the bottom of this slide. It was the second issue in 2024. It's a completely open-access issue of Seminars in Hearing.

And in the chapter six of that issue, it goes through step by step how to use a hearing aid verification system to do hearing protector fit testing.

Okay, going. I see a question about sound field testing, which I'll answer real quick while we're on the on topic. Hearing protector fit testing is always done with narrowband noise, so you would want to use narrowband noise in your sound field and when you're doing the sound field testing for hearing protection. Okay. Now, no matter which method you use, whether you're doing sound field audiometry or hearing hearing aid verification system to get some real ear

insertion gain values, you could stop there because you'll have octave band noise reduction levels across a range of frequencies.

And that might be enough to just help you kind of eyeball up and say, yep, this person is fitting the hearing protector and getting sufficient attenuation. Or they're not, but we can go a step further and actually calculate the par. Dedicated hearing protector fit tests and systems will do this for you automatically, but you can do it yourself based on the octave band measures that you noise reduction measures that you get. I'm going to walk you through this slide. Please don't panic.

It's not as complicated as it looks. If you happen to know the octave band noise exposure levels of the person that you're testing is exposed to, you can put those in the top row of this little table that walks you through the calculation. Frequently. We don't have octavan measures even occupationally. We usually only have a single number, a weighted noise level.

We don't know the octave bands. When you don't know the octave band measures of the of the particular noise exposure. Or if you want to just get a general PAR that can be applied to multiple noise exposures, we use an assumed pink noise, 90 dB in each of those octave bands. Because PAR is designed to be applied to an A weighted noise exposure, we then subtract the A weighting values off those 90 decibel octave band measures and that gives us the weight the a weighted octav band measures which we then combine across frequencies to get a single a weighted level. And don't panic.

You don't have to go by hand and convert this back to pressure and then reconvert it back to db. There are decibel calculators all over the Internet. I've got a link on this slide to one that's on the National Hearing Conservation Association's website. So you just type in your octave levels and it automatically tells you what the overall a weighted level is. From that, then you would put your octave band noise reduction values that you either got, you know, through doing sound field testing or running through the hearing aid verification system.

You put how much noise reduction you got at those octave bands that gives you a weighted protected octave band levels. And again you throw those into your DB calculator and you get an overall a weighted protected exposure level. So in this example, the a weighted protected exposure level is 74 DBA and PAR is simply the noise exposure level, which we're using an assumed pink noise, which comes out to be 97 DBA minus the protected exposure level, which in this case is 74 decibels. And then we also subtract off a 3D kind of factor for uncertainty. Since we don't know the exact noise level that these are going to be used in, we just kind of subtract off 3dB for uncertainty.

So this PAR level for this particular fit test would, would be 20dB. And par is designed to be subtracted directly from the a weighted exposure level. So it's very easy to use. So if your patients or clients have like a noise app and they go

to a concert and they just pull the noise app out of their phone and they, they make a measure and they say, hey, it's 96 DBA here and they know that they've had their hearing protection fit tested and, and their par is 16 DB. They can just, you can just subtract that right off.

The result is their protected exposure level is 80 dB. And that's right in that target range. That Wei talked about when we want to get a protected exposure level, a protected exposure level somewhere between 70 and 85 DBA. So using par is very easy once you've gone through and made those calculations.

I want to spend just a few minutes here towards the end to kind of talk about some best practices in choosing and recommending hearing protection. It's really important to offer a variety of different types of types and styles. We use the analogy of, you know, ill fitting shoes or shoes that people find uncomfortable. And everybody has kind of different tastes or comfort levels in particular footwear. And it's exactly the same with hearing protection.

Some people find foam earplugs uncomfortable, some people think they're fantastic. So it's really important to have a number of different types and styles that people can choose from. And as we're hoping you figured out after, as we get to the close of this webinar, you should not be selecting hearing protection based on the nrr. We like to say it's not really relevant. You want to focus on issues like communication.

How well can they hear through the hearing protector, how comfortable is it? Is it compatible with other things they're wearing? Whether you know, that's, that's hats or eyeglasses or you know, is it convenient? Will they be able to keep it nearby and use it whenever they're exposed to noise? On the NIOSH website we've got kind of a short and sweet blog that gives you kind of three main tips to keep in mind when you're choosing a hearing protector.

So just leave you with that. And then also, as we mentioned, training is super, super important. We tend to think that hearing protection is kind of just self explanatory. Put the earplugs in. What, what is there to what, how hard can it be?

But, but it really is. Murphy's law is so true here. Any protector that can be worn incorrectly or will be worn incorrectly and just spending a few minutes, it usually does not take very long to explain to people the right way to put a hearing protector in. Pulling back on the ear to straighten the ear canal, rolling a foam protector all the way down and holding it in place for a few minutes so that it can completely expand. These go a long way towards making sure that people will get the right amount of attenuation out of their from their hearing protection.

And that we see frequently when we work with folks in hearing protection that there's like this aha moment that they're like oh, oh, that's what it's supposed to feel like or that's what it's supposed to sound like. And then that gives them a frame of reference moving forward and it makes it much more likely that they'll be

wearing their hearing protection correctly moving forward. We often get asked what's the best kind of hearing protector? And I'm going to just tell you, there's no one answer to that question. The best hearing protector is the one that will be worn correctly and consistently whenever someone is exposed to.

I want to just talk. This chart here shows why consistency is so important. I mean obviously correctly is important. We need them to get enough sound reduction and we've talked about that. But it's also important that they wear it consistently so that they wear it every time that they're exposed to hazardous noise levels.

And this chart illustrates the effect of not wearing hearing protection even for very short periods of time. So it's based on an assumption that a worker is going to wear their noise, their hearing protection for an eight hour shift and that the effective protection that they're getting from the hearing protector is 25dB. And as you follow this blue curve horizontally across the chart. You can see that if they just take that hearing protector out for just a half an hour, their effective protection goes from 25 down to 17 dB. And if they take it off for half the day, their effective protection drops all the way to 5dB.

So you know, a lot of times people tend to think, oh, I'm just going to be in the noise for five minutes and that's not going to last very long. I'm not going to bother with your impet. But not wearing hearing protection consistently really does reduce the amount of protection that you get. Real briefly, I'll just touch on the fact that as Wei mentioned, hearing protector testing aligns with current governmental policies and recommendations. Just about a year ago, NIOSH changed its policy from the derating scheme that we showed to recommending that all employers use individual quantitative fit testing to evaluate the attenuation workers get from their hearing protection devices.

And OSHA also in most circumstances allows. OSHA is the Occupational Safety and Health Administration. It's the primary labor regulation body in the United States. In most cases, OSHA also allows hearing protector fit testing to meet its regulatory requirements.

I can see we're running kind of short on time. So just there, there were a couple of examples that we have of success stories that where hearing protector fit testing has been applied in certain companies. These are companies that won a Safe and Sound award for their excellence in hearing conservation programs. This one was from a 3M plant in Hutchinson. They did a pilot test to demonstrate the value of fit testing to management.

And when they initially tested the small group of 85 employees, only about half were getting sufficient noise reduction. And after retraining and switching to different earplugs when necessary, everybody but two was able to get proper attenuation. And this enabled this convinced management of the value of hearing protector fit testing. They expanded it to the whole plant in Hutchinson and eventually other 3M plants have also done the same. And this plant, this was a

paper mill in Cottonton, Alabama, a 50 year old plant, really challenging noise issues, really high rate of hearing shifts.

And when they started they launched several initiatives to try and fix the problem. One of the things they did was start to include hearing protector fit testing. And the left, the leftmost bars on this graph show the last year when they were not fit testing. And they had 28 hearing standard threshold shifts, which is a significant change in hearing that's used in occupational noise monitoring or hearing monitoring. And then once they implemented fit testing, the rate of standard threshold shifts dropped dramatically and has remained much, much lower.

I'm going to point you to an introductory guide that you can find on the National Hearing Conservation Association's website. It wasn't designed for audiologists, I'll tell you that just straight up front. It's designed more for occupational safety and health professionals who do hearing protector fit testing or hearing who are doing hearing conservation and industry. But it does have a lot of good basic information. It would be a good review from everything that way.

And I have covered. And also in the very back of this document there's a table. If you are considering buying a dedicated fit testing system, there's a table there that kind of outlines the considerations you know how to how to determine what fit test system might be best for you. So in summary, hearing protector fit testing really does prevent noise induced hearing loss. We think it can expand and enhance your clinical practice practice and to ensure that noise exposed individuals are properly protected.

Identifies problems with over and under protection. Provides real time feedback to patients and clients where they get that aha moment like ah, I know how to fit my hearing protectors now. And it does meet federal and policy requirements. Best practices Remember that hearing we should always recommend hearing protection to our patients and clients anytime the noise level is 85 decibels or higher. We want to offer them a wide variety of hearing protectors so they can find something that works for them.

Focus on factors other than the NRR when you're selecting a hearing protection device. Use fit testing to ensure proper attenuation and definitely provide one-on-one training on hearing protector use. It only takes a few minutes and it makes a huge difference in how well that hearing protector is going to work for someone. So we thank you for your attention and for joining us today. I know we run a few minutes over, but if we have a minute or two for questions and there are any, we'd be happy to try and answer them.

Actually see one question.

Is it pre molded earplug, custom earplugs or stock foam earplugs? Oh, I should have answered that sooner. I'm not sure what that question's referring to. And I think we answered the second one with regarding whether or not there's a

question, are you using warble tones or narrowband noise for sound field testing? And for hearing protector fit testing we always use narrowband noise.

All of the test systems do. And then when you're doing soundfield testing you would want to use narrow band noise. Perfect. I think the first question is asking are pre molded earplugs custom or stock? Oh, oh oh I.

Okay, I understand. Thank you, Carolyn. I understand the question now. So a pre molded earplug is, it's not a custom, but it, it's not a foam. So foam ear plug can be rolled down and it expands to the shape of the canal.

But a pre-molded earplug is made of plastic. It's usually some sort of soft rubber or plastic. It has like different flanges that are, that are designed to kind of fit most ear canals or they come in different sizes. So they're, they're not custom, but they're not roll down. They're, they're preformed.

They're made in a particular shape. Thank you. Got you. Thank you both so much. I mean when I was thinking about all of my time in clinic with patients who were fitted with receiver-in-canal (RIC) hearing aids and how many times they're coming in with the, you know, the receiver hanging out of their ear or the, you know, the, the tubing, like the, the devices hanging off their ear because the tubing isn't right.

I mean the same thing is happening from what you're describing with, with hearing protective devices, right? Yes. They're not seated correctly. So it makes a lot of sense. And as we talked today about scope of practice, practice with audiology, I mean this is something all audiologists should be doing.

We, I'll say the word should.

We are the experts. We should be the ones doing this, counseling our patients, getting, having them get the most use out of it. And so much of it I would assume is just awareness as well. Somebody knows they're wearing it wrong, bringing that to their attention right there because make a big difference. So thank you both for this amazing presentation.

Thank you for leaving your contact info. So if folks have follow up questions, they will reach out to you and we hope to have you back again. It's really been a delight to work with you both. It's been a pleasure to be here and thanks for inviting us to present. We appreciate it.

Thank you. Thanks everybody. That wraps today's webinar. Go get ice cream. Bye.

Bye.