Managing the Musician with Hearing Loss: Fundamentals and Diagnostics, presented in partnership with Salus University

Presenter: Brian J. Fligor, ScD, PASC

At this time, it is my pleasure to introduce Dr. Fligor who will be presenting Managing the Musician with Hearing Loss Fundamentals and Diagnostics presented in partnership with Salus University. Dr. Fligor is a board certified pediatric audiologist and Chief Audiology Officer at Lantos Technologies in Wilmington, Massachusetts. He maintains a private clinical and consulting practice, Boston Audiology Consultants, geared towards diagnosis and treatment of hearing disorders in musicians and audio professionals. Prior to joining Lantos, Dr. Fleigar was director of Diagnostic Audiology at Boston Children's and Assistant professor at Harvard Medical School. He is adjunct faculty at Salus University and a consultant member of the Children's Oncology Group, Chair of the World Health Organization Make Listening Safe Task Force on Manufacturing Standards of Headphones, and founder and past chair of the Music Induced Hearing Disorders Task Force for National Hearing conservation association.

Welcome, Dr. Fligor, and thank you for being with us today. Awesome, Christy, thank you so much. I appreciate you all having me here. This is really exciting. So, as Christy noted in my bio, I'm an adjunct faculty at Salus University.

The course that I teach there is called Managing the Musician's Ear. And so here, this is in conjunction with Salus University. And so I want to give a gracious thank you to Radhika Aravamuddin. Can't pronounce her last name correctly, but she's the new dean at Salluster University, GSO College of Audiology, and as well to the rest of the faculty who are there. It's really, it's a lot of fun being able to participate with that.

So this is the first presentation of two presentations that essentially covers a semester's worth of information in, well, two hour and a half long presentations. All right, so folks, as a disclosure, you know, certainly I own my own private practice. I do some technical consulting to some manufacturers. I am also, I'm a consultant to Lantos Technologies. My role there is as Chief Audiology Officer.

I am going to be showing a couple of things that are specific to Lantos. Know that I am a part owner of that company and so please take anything. I may say that it's glowing reviews with a grain of salt, but I think that the content itself stands on its own. I'm chair of the working group, the WHO working group on making Headphones Safe. So while all headphones can be used safely, they can also be used unsafely.

And the group that I chair for WHO is looking to try to establish some guidelines to essentially give audiologists a little bit more of a hand into what's going on with these with the headphone and elevate our role in the hearing healthcare provision. Okay, so a couple of things that I want us to focus on and think through. What are we going to try to accomplish here by 1:30, I want you all to be able to describe limitations of applying the occupational noise safety standards, the OSHA standards, for instance, or NIOSH standards, that there are some limitations to being able to apply those for musical exposures. We I want you to be able to explain the relative risk of developing a music induced hearing disorder. Notice I don't say a noise induced hearing loss.

I say a music induced hearing disorder for the specific musician. And that's based on detailed history as well as a sound survey when you have an opportunity to do so. There's some very specific things to think about in doing an audiological evaluation with musicians. It's not just about making sure that you test 3,000 and 6,000 Hertz in addition to 4,000, looking for little modest notches. There's a couple of pieces in that that I want to highlight for you.

And yes, this today is about fundamentals and doing the diagnostic evaluation, but it is also going to be about some of the hearing protection devices that we may end up using. So there's a little bit of a bent toward the treatment side. And, you know, if we think about prevention as being treatment, this very much is down that path. The next presentation that I give, which is going to be next week, it is going to be on treatment and specifically going to be geared toward tinnitus therapy as well as hearing aid

fittings for musicians. Those are things I'm not going to get into today.

So overall, I think it's important for us to be on the same page in terms of thinking about the terminology that we might use. We're going to go into our diagnostics and into our hearing protection, just as I noted with our with those learner outcomes. I only have three main topics here today. If you walk away feeling like you've got quite a deep understanding on each one, then you're definitely getting ahead of the game. Okay, first thing, I think I would imagine many of you who have chosen to participate in this live presentation or who are going to listen to this in the recorded presentation are going to say, all right, I see musicians.

Well, this person isn't quite a musician. I mean, they just, they're a hobby musician. They play guitar with a group on the side. You know, is this person a musician? Well, he's a sophomore in high school, but he plays in the drum line.

And yes, Parents are really concerned about their kids hearing, but the music instructor really is highly resistant to doing anything different. And I can completely appreciate the music instructors needing to be able to make decisions on how best to educate their students. Well, in the grand scheme, whether or not somebody is a musician is if they say that they are a musician, it's not just about whether or not they have formal training either in, you know, in high school or younger or college, or if they're, you know, making a living doing this. You know, certainly a number of incredibly talented musicians and people who are exposed to sound that is capable of causing a music induced hearing disorder. They may have never gotten paid for their performance, they may not have any formal training, but nonetheless, they're still our patient.

And their values related to what they can hear and what they need to hear and what they need to be protected from, it is a shared experience. Whether this is a 16 year old playing in a rock band in his parents basement or it's a member of the Chicago Symphony Orchestra who's first chair violin. There

are some shared experiences. And that's what we're going to be talking about mainly. And this is where I love to quote Binge Kantors, who's a professor at Columbia College in Chicago.

Music professionals need an audiologist the way everyone else needs a dentist. If we think of it down that path, then that helps to define who is a musician. Yes, I completely agree. You know, five year olds need to have their hearing checked. All of them need to have their hearing checked before they go off to kindergarten.

You know, our. When a person becomes Medicare eligible. Absolutely. As part of their enrolling in Medicare should be referral to, you know, proctology to get things checked out there, you know, getting your vision checked. Because cataracts are definitely a concern that's going to start coming in.

See a dermatologist because certainly we need to be concerned about skin cancer. We also need a hearing test because we know that it's a really high rate of people with hearing loss when they're 65 and older. Guess what in that say, you know, elementary school age right up into the mid to late 50s. We know that this is a range of people that just don't access audiology services unless they absolutely have to. And it's the musician that I would argue who needs much more frequent and capable contact with an audiologist because they need an audiologist the way everyone else elementary school through their 50s needs a dentist.

So thinking this through, this is about our terminology piece. Okay, who's a musician is it just somebody who plays an instrument. What about those people who present a lot of sound and are in a lot of sound, like DJs, like the music producer, a music promoter, who's somebody who's at shows all the time. And their job literally is to help to make contact between a musical group and, you know, the labels, the record labels who actually, they may, believe it or not, still be able to make some money. You know, the tour producers.

These are people that, you know, frankly, this is how musicians make their money these days, is by doing live tours. So just because a person isn't a member, quote, unquote, member of the band, say they're part of the crew, they're doing load in and load out, or they're the sound engineer. These people are technically musicians as far as the audiologist is concerned. So how about consumers? You know, perhaps we have some members of the audience who would have been classified as Deadheads.

There's friends of mine who go see Darkstar Orchestra, which is a group that. They're a jam band, they tour a lot, and they have people who literally just follow them town to town to town to hear them. You know, there are people that I've taken care of who go see shows at least once a week, if not three or four times a week. You know, there are people who I take care of that they're not going to the live venues. These are people who may have a desk job, but the work that they do, they like to have some, you know, some music going on.

And they literally will put their headphones in at the beginning of the day and they leave them on until they get off their subway when they get home at night. And we're talking about a good 14 to 16 hours of exposure every single day. So are those people musicians? Well, technically, again, from the perspective of the audiologist, yes, they are. Now, let's think about what it is that we want to evaluate them for.

It's for music induced hearing. Music induced auditory injuries. Music induced hearing disorders. Okay. Or what I'll refer to here today as MIHD hearing disorders.

We don't talk about within the musicians, the word loss kind of brings about a certain negative connotation that actually will interfere with their accepting of recommendations. It'll interfere with their engaging with you in the first place. So if you talk about an injury, well, that's something that is well understandable and it makes sense. And it's a thing that happened to you and there was a negative consequence of it, and we need to do something about it. A disorder, you may think of that as being

something that is an ongoing condition that is secondary to that injury itself.

That's why I kind of give those two a little interchangeably. There's an injury of the actual cause of whatever happened, whether it be noise induced permanent threshold shift or nipts, also noise induced temporary threshold shift, nitts, that's that noise notch, a notch in the audiogram, typically with the Deepest point around 4,000 Hertz, but could be the deepest part, could be at 3,000, could be at 6,000. With better hearing at around 2,000, or at lower frequencies and better hearing at 8,000. And at higher frequencies, frequencies, at least until presis sets in, you start to have more of a high frequency loss. But in fact, rather than a steeply sloping loss, you may get more of a bulge where you get quite a lot of loss around 3,000 to 4,000 hertz.

And yes, that higher frequency may come up a little bit, but it's still down far. Think about that noise induced permanent threshold shift, as this is the thing that we can test for and we can see really easily all the time on our audiogram.

When you talk about hearing damage, that's another term that I think is a little bit challenging for us to say. The musician themselves, they drive a car, as most of the rest of us do, and you get into an accident, your car gets damaged, well, you go and you just have it repaired or replaced and it's right back to the beginning. You don't talk about your car getting injured. All right, I talk about my guitar that I, you know, it fell off its strap, it dropped to the ground, it cracked the body, it's been damaged. And I can either have it repaired or I get it replaced.

Our ears were not repairing and or replacing those. They have been injured. And it's that injury that results in some kind of disorder that needs to be addressed. These other disorders, you know, injuries that result in other disorders are things like tinnitus, abnormal pitch perception, or perhaps a distortion that happens in there. And this is globally, I generally refer to it as diplocusis or loudness intolerance.

Not necessarily like recruitment where we have hearing loss and it's, you know, loudness, discomfort levels that are a little too low. And this is just part of having cochlear hearing loss. This loudness intolerance I'm referring to is where loud sounds that would be tolerable to you and me, but they'd sound loud, are painful to the person with hyperacusis. Oftentimes people have A range of all four of these music induced hearing disorders.

However, they may have a lot more of one than of another. The reason why they're coming to see you may have absolutely nothing to do with their permanent threshold shift. In fact, more often than not, whether someone has a noise notch or they don't have a noise notch, that's not why they've come to see me. They're coming to see me because they have tinnitus. It's the number one reason why people come to see me.

One of the other reasons people come to see me is diplocusis. I actually just had a gentleman this morning. He's in his late 60s, professional, doing an office job, but he plays piano in a jazz group. And he had a, an auditory injury about five years ago where someone was, the guitarist was using his amp, it was cranked up really loud and he was using his Wawa pedal and he did something with it or the pedal broke and it literally just had a white noise screech that just immediately erupted out of the amplifier. And unfortunately, the guy was right there in front of the amplifier.

And so one of his ears, he gets a distortion and it's off tune every time they start playing at a modestly loud level. And it's actually a level dependent diplocusis, mainly in his right ear. His left ear probably has some of that too. I want to talk a little bit about how would I go about evaluating somebody with diplocusis. These are separate entities that are part of the diagnostic process.

And yeah, it can get a little bit weird and scary because oftentimes we didn't get this kind of training in our clinicals when we were students. But we can take what we've known, what we learn, what we know about testing someone's hearing, and apply some of the similar clinical decision making to evaluate,

well, how bad is their tinnitus and what do we do about it? How bad is their dipacusis and what do we do about it? How bad is their hyperacusis and what do we do about it? So very basic stuff, but really important for us to all be on the same page.

How does noise damage hearing? And of course, again, where terminology is concerned, we may want to think about taking the word noise because music is not noise. We may think about changing that word noise and saying sound. How does sound damage hearing? But for most of our existence as audiologists, we've been talking about noise induced hearing loss and noise induced permanent threshold shift.

So I'm going to stay with that nomenclature for now. But I just want you all to cognitively make a little switch in your brain. Alright? So 85 decibels is not safe. 90 decibels is not safe.

Well, it is safe if it's for a very short period of time. In fact, 85 decibels would be perfectly safe for an hour in most people's ears. It's about the level over time, not just the level. So what is the softest sound that or sorry, let me back up. What is the loudest sound that does not cause noise induced permanent threshold shift in anybody?

That's not really easy to answer, but the best summary I can give you is 75, 76, 77 decibels of broadband. A weighted sound will not do damage in anyone's ears for any, and I apologize for any period of time, okay? For any period of time. It will not cause any kind of auditory injury. Okay?

So at 78 decibels in highly susceptible ears, you can get a little bit of a permanent threshold shift at around 4,000 hertz in some people. Now this is if you're exposed for really long periods of time. We're talking 16, 18, 24 hours over a long, long stretch. For instance, in some highly susceptible people, they can get a lifetime sound exposure from riding the subway in New York City of like around 78, 79, 80 decibels. And in some people, they will actually develop a little bit of hearing loss.

Okay, the primary site of lesion that, and this is being tested right nowadays when we're thinking about things like hidden hearing loss. But the primary of lesion has historically been understood to be the outer hair cells, principally because they are the most metabolically greedy cells in the auditory system. And when you overload them with high level sound over time, they end up poisoning themselves with the waste product that is part of the process of the hair cells doing their little twitch.

That little twitch that is a very greedy little process. And if they over of the waste product getting swept up by antioxidants that just naturally circulate through our body, the amount of waste product can overwhelm that and cause the cell to go into a programmed cell death cycle called apoptosis. And so it can literally cause the cell to say, wait a second, we're not going to live. Rather than die a terrible explosive death where the cell guts actually rupture and causes inflammation and further widespread destruction, the cell itself can say, you know, we're just gonna, we're gonna unravel our DNA, we're gonna break into little bits and pieces we're gonna maintain the integrity of the cell wall and the cell will literally just disintegrate and extend off and float up into the, into the endolymph. That's a nice way to die.

Now, of course, unfortunately, it means that cell died and it's not contributing to the active process of hearing. And when you lose enough of those, your otoacoustic emissions are going to start to decrease and they're eventually going to go away. Your pure tone thresholds are going to stay normal for some period of time. And eventually, if you have more damage, more damage over a wider spread area now you're going to start to have a pure tone threshold shift. Now you can get a noise induced temporary threshold shift.

And this is partly due to, it's due to a couple of things. Breakage of the tip links, the little link that goes between the stereocilia on primarily the outer hair cells, but also the inner hair cells, as well as a swelling of the auditory nerve fiber. It's this, what's referred to as an excitotoxicity, the neurotransmitter

that the inner hair cell releases when it's stimulated. That neurotransmitter is glutamate. And glutamate is good.

It goes across that synaptic junction, that little space between the base of the inner hair cell and the auditory nerve fiber. And that glutamate just crosses over and it causes that nerve fiber, says, oh, hey, depolarize. And it does. And an action potential fires and extends up along the axon of the neuron. And hey, that's perceived as a sound.

When you get too much glutamate going across that and just overwhelms the cell itself, the neuron, you can get a swelling. And that swelling can actually cause that neuron to just be less sensitive to sound that it was previously sensitive to. And that is a temporary, that results in a temporary threshold shift. So when the cell is given time to rest, it can recover and the tip links can reattach and the cell can start to respond again, both the outer hair cell, inner hair cell and the neuron. And so you get a recovery.

However, there is concern. This is particularly some of the work out of Sharon Kajawa at Eaton Peabody Labs and Charlie Lieberman, as well as some others who have done a lot of good work on hidden hearing loss. We do know that sometimes a temporary threshold shift can result in those auditory neurons dying off and being pruned away and pulling back, which can result in tinnitus. It can result in difficulty hearing and noise. And so even though you may have a normal audiogram, you can have a neural damage that's done from what you thought was a relatively benign sound exposure.

Typically speaking, at least in the animal models, the amount of threshold shift, that temporary threshold shift has to be enough that it almost results in an acoustic trauma where you have an immediate permanent loss of hearing, but didn't quite hit that threshold. It recovered all the way back to the baseline audiogram, but it was such extensive noise induced temporary threshold shift, that's a little surprising. You didn't get a permanent. So that leads into our next point here about. Well, how does noise damage hearing?

You can damage hearing from an acoustic trauma. I mentioned the musician that I saw just this morning who had some mechanical malfunction of the guitarist's Wawa pedal and his amplifier. Well, something happened where there was this really relatively brief, but a massive overdose. And that can result in a mechanical damage to the auditory structures after a single exposure. It results in immediate loss of sensory hearing.

It doesn't always have to be a permanent threshold shift like an audiogram shift. It typically is, though. But along with that, you almost always have tinnitus. It's almost an absolute one for one, that if you have an acoustic trauma, you will have tinnitus. Now, is that tinnitus bothersome?

Is it clinically significant tinnitus? That depends. That depends on a couple of things that we will talk about later when we step through the inventory. All right, so folks, we're about 25 minutes into it and, you know, we've got another hour or so before I'm going to open up to questions, take a break and think through. Okay, we talked about a couple of pieces around terminology, talked a little bit about the underlying science of how noise damages hearing.

We're going to start to apply this a little bit as we go forward. So how do we know that 78 decibels, up to somewhere in the high 100 30s, causes hearing loss if you're exposed to it for a long enough period of time, Often enough. We know this from a few finite data sets. And one of them I'm showing here on the computer screen is called the Occupational Noise and Hearing Survey, commissioned by niosh, the National Institute for Occupational Safety and Health. This was conducted over 1968 to 1972.

So these data are a little bit old and it's actually a little bit limited in reality. 792 workers who worked at manufacturing plants, principally around the Great Lakes in the United States. So the idea Was, let's take these people. So along this Y axis, this is the number of years that they worked at this manufacturing plant, okay? That's along the Y axis is of years of exposure along the X axis, this is the

sound level in decibels.

And this was averaged out over an eight hour time weighted average. Alright, so if they were exposed to 85 decibels for eight hours, okay, you're gonna be in 85 dB. Okay? If you're exposed to 88 decibels for four hours, you're actually an 88, 85 decibel for eight. If you're exposed to 91 decibels for eight hours, OKAY, well now you end up at this 91, but it was weighted out over how many hours per day you would be exposed.

But that of course is assuming that where this person worked in year one is where they worked in year two, in year five, in year ten, and in year forty, and that their sound exposure didn't really fluctuate very much from one to the next. Now the researchers in particular, Don Henderson, who's just, he's one of the gurus of this, he passed away not long ago and we're sad for it because what an outrageously gifted researcher. He was one of the people who participated in this study as part of his work. They did a very good job of weeding out those people that they couldn't really define what their sound exposures were over the course of their working lifetime. So this is over that working lifetime.

They had a smattering of data here between 80 and 85 decibels.

What we take away from this is the people that were exposed for over 40 years at say 82, 83 decibels, did have slightly worse hearing than people down here who are only exposed for a year or two. But it wasn't that big a difference because most people around 80, 82, 83 decibels, their hearing doesn't shift a whole lot. These people who are exposed to really high levels, well over 100 for a year or two, they'd have hearing loss, but not as much hearing loss as these people here. Now bear in mind this is only three individuals. It's not a lot of data.

What we have really good data on is between roughly about 85, 86 decibels up to about 95 decibels. So this more tightly packed data set here right in the middle gives us better opportunity to predict. If I'm

exposed to 92 decibels for 10 years, I have a pretty good idea how bad my hearing is going to be. And if I've been exposed to 92 decibels for 40 years, I have a fairly okay idea what my hearing loss is going to be. But not as good because there's not as many data points up here.

So our estimates get a little bit worse. So our estimates for 85 decibels to 95 decibels for up to 20 years are pretty good. Longer than 20 years or lower than 85 or above 95. And our predictions get a lot, excuse the pun, they get a lot noisier. That said, that's all we've got.

Those are the data sets. We're not going to go back and repeat those. Here's what we do know based on those data sets. So osha, looking at, well, what should the minimum standard for safety be? Let's define material hearing impairment.

Okay. Of These people, these 792 people, if we allowed them to be exposed to 90 decibels for that working lifetime of 40 years, what percent of them would sustain a material hearing impairment? Well, ISO, EPA and NIOSH all put statisticians on this and they came up with their own estimates, their risk estimates and it was from 21 to 29% of people would develop a material hearing impairment if we gave them a 90 decibel exposure. If we gave them an 85 decibel exposure, then it would be from about 10%. 12 to 15% would be at risk for material hearing impairment at 80 decibels.

Anywhere from that, none of them would be, but 3 to 5% might be. Now there is a reanalysis conducted with more up to date statistical metrics and this is something that paper was published in Jazza in 1997. Lead author is Prince. This is what, what created the new standard that NIOSH bases their their own damage risk criterion on. As in NIOSH would consider 85 decibels for an 8 hour exposure to be the maximum.

The maximum recommended exposure or the maximum recommended exposure level is 85 decibels for eight hours with a time intensity trading ratio of 3 decibels. And we'll talk about what a time intensity

or an exchange rate would be and how that relates to damage risk criterion. So OSHA said, yeah, but hearing loss is expensive to prevent and we're going to be very pro business. And bear in mind that in the early 80s the Reagan administration was running the show and OSHA is under the Department of Labor, which is part of the executive branch. And the Environmental Protection agency through the 70s had a noise office.

Noise is a pollution. It's a pollutant, it is considered pollution. Excuse me. And there was an office in the EPA that was dedicated to the evaluation, to the measurement and recommendations regarding what to do about noise. This is principally community noise, like, you know, traffic noise, trains, airplanes, etc.

Well, during the Reagan administration, the EPA's noise office was defunded. There is a law that says the EPA is required to measure all these different pollutants, and one of those pollutants is noise. Except the executive branch has not funded the EPA's noise office since the 1980s when Reagan came in, and it's never gotten its funding back. Which back in the 1970s, the EPA provided us awesome information, awesome studies and analyses around noise exposures and community noise exposures in particular. And because we've defunded it, we've lost out on a lot of really good information that we might have otherwise had.

Anyway, off my soapbox there. Let's just say that our current understanding for how loud is too loud is based on the Prince et al study looking at 85 decibels. For an eight hour time weighted average, 8% of people will sustain a material hearing impairment if they are exposed to this over their working lifetime. So what's a material hearing impairment? Well, that's actually gone through a few different definitions, but generally speaking, it's a weighted average at 1000, 2000, 3000 and 4000 Hertz.

That is greater than 85 decibels. Sorry, greater than 25 decibels. My brain is stuck on 85 greater than 25 decibels. All right, so you know, because borderline hearing loss is about 20 to 25 dB. And so

greater than 25 dB hearing loss, as in 26 decibel hearing loss is considered a mild hearing impairment.

And so it's an average, a speech weighted average across 1,000 through 4,000 Hertz. Here's an audiogram that is just beyond the cutoff of a material hearing impairment. This audiogram I'm showing, this is a material hearing impairment. This is the exposure that 8%. Well, this is the amount of hearing loss that 8% of people will have this much loss or more if they are exposed to 85 decibels for eight hours over the course of 40 years.

25% of people, roughly 25% of people will have this much hearing loss or more if they're exposed to 90 decibels or greater for their working lifetime. 3% of people roughly will have this much hearing loss or more if they're exposed to 80 decibels for their working Lifetime. Now I keep using this term working lifetime. That's from year zero through year 40. And not a lot of people work at the same job for 40 years straight.

But a lot of people are exposed to noise their entire lifetime. And so if you imagine someone who comes out of trade school when they're 20 years old, Carpenter, plumber, electrician, and they're working in their trade for this duration of time, police officer, for instance, who has to qualify on the range, they are going to develop some degree of hearing loss. And even if they are protected, they may develop this much hearing loss or worse if they're on that more susceptible side. So different organizations come up with different criteria for what's considered okay. It really all depends on how much hearing loss are you trying to prevent.

If you are trying to prevent just enough, just enough hearing loss so that you're, you know, not going to be fined by government regulators. OSHA makes it very easy to get away with injuring your workers. Sorry, osha, that's just. This is part of the standard. Your maximum permissible exposure level is 90 decibels for an 8 hour time weighted average with a 5 decibel exchange rate, meaning that for every 5 decibel increase in the sound exposure, you're allowed only half the time.

So from 90 decibels to 95 decibels you go from being allowed to be exposed for eight hours to being allowed to be exposed for four hours. Now, OSHA, there's an amendment that says actually that may be the maximum permissible exposure level, but there's an action level that says, but wait, people have to be enrolled in hearing conservation programs if their exposure is 85 decibels or higher. Of course, that 85 decibels is if you have a 5 decibel exchange rate. So you can be exposed to 90 decibels for 4 hours or 95 decibels for 2 hours as you get to higher and higher sound levels. The difference between these different from very liberal criteria to very conservative criteria, it matters a lot.

So 90 decibels, 85, 80 decibels for eight hours. These are, you know, modest, significant differences, I would say, but eight hour exposure allowed. However, the epa, which EPA and World Health Organization have adopted a standard that is basically, it's trying to prevent all noise induced permanent threshold shift. 80 decibels for an 8 hour time weighted average with a 3 decimal exchange rate. This is what's considered the maximum exposure if you want to Prevent hearing loss.

80 decibels for eight hours, 83 decibels. So it's a three decibel increase now for half the time, 86 decibels for half the time, 89 for an hour. Contrast that with NIOSH, which says, well, we are going to allow 8% of people to sustain a material hearing impairment. You can be exposed to 94 decibels for one hour. OSHA says we're going to tolerate.

Well, we want you to be enrolled in a hearing protection program if you're at 85 decibels. But we will tolerate by law, up to 25% of people developing a material hearing impairment. So those are some of the differences in what is considered too risky versus, you know, reasonably. That's okay. We're going to allow you to be exposed.

So is music noise as it relates to all these damage risk criterion?

Yes and no. Really is the short answer to it is music noise? Well, the question might be, can music damage your hearing the same way that noise damaged the hearing of those 792 workers that were part of the Occupational Noise and Hearing Survey? Well, music is not constant. It's not this constant.

Well, it's a little bit more with compressed music and, you know, streaming audio. But historically and still there's a lot of more dynamic range. There's quiet periods in it, but there's also transients on top, like a snare drum beat or a cymbal crash. So there's some transients as well as some rests. It it's time varying.

And the more rests you have in the music, even if the amount of energy that is conveyed in that same song, the more rests you have, the less damaging it is. However, the more transients you have, like more beats, more snare drum hits or cymbal crashes in a song, even if it's equal energy, that can be slightly more dangerous. So music dynamic range is really just enormous. It's actually somewhat difficult to define what it is. But live music may be down as low as about 30 decibels.

Sound pressure level, that's four Ps it's not pianissimo. It's the quadruple P. So it's the softest and still making sound all the way up to triple F. Not fortissimo, but one forte fortissimo, you might have levels up around 120. And that's in principally in the bass section or in the percussion of the actual musician. That's the physical distance they are from the sound source. So for instance, the bell of the trumpet when they're playing up at this highest level.

So we've got a good. Well 90 decibels of dynamic range. Contrast that with speech's dynamic range which is around 30 to 35 dB. Speech's crest factor, so it's RMS to its peak. If the RMS of speech is 65dB SPL, the peaks of speech end up being around 77dB.

With music, it's instrument dependent, we don't know. You can't really easily define what is the RMS of music. But the peaks of music are 18 to 20 db higher. So the transients of music are greater than the

transients of speech, for instance. And that's mainly because in speech we're actually, we're producing sound through our vocal tract, which is soft and wet.

And in our instruments, our woodwinds, our brass instruments, these are dry and hard. And so you actually have less damping of these peaks going through the tract, vocal tract wet and soft, the tract of a trumpet for instance, hard and dry. And it has a significant difference in the peaks. So because we have time varying difference, whereas with the standard definition of noise from occupational noise, we have a lot more time varying, but we also with rest as well as with transients in it, we have a greater dynamic range. We also have a larger crest factor where the transients are higher.

In music, the damage risk criteria are based on steady state noise, occupational steady state noise. We do not have a damage risk criteria for music full stop. We don't have a damage risk criteria that's appropriate for music.

That said, we do know that sound exposure from, you know, music exposures do result in some kind of hearing disorder. Kim Kahari did a published a great study in 2003 of 139 rock and jazz musicians, average of 25 years experience found hearing disorders. So this is noise induced permanent threshold shift, tinnitus, etc. In 74% of people of their musicians. Santos published study in 2007.

This is in DJs so recorded music. Their exposures, their average 5 minute exposure levels were 93.2 up to 109.7. Pretty wide range. Well, of their 30 subjects, 11 of them came into the study with some noise induced permanent threshold shift at baseline and they measured their thresholds pre exposure, measured their thresholds post exposure, also measured otoacoustic emissions pre and post. And they showed reduced hearing sensitivity by audiogram pre versus post exposure.

And they showed a reduction in the otoacoustic emission magnitude pre versus post exposure. So we do know that their sound exposures resulted in some kind of shift in their auditory function. Absolutely

phenomenal study. One of the best ones that's been done in musicians was Royster, Royster and Killian, as in Mead Killian doing some measures of the Chicago Symphony Orchestra. You had there were 68 exposure measures.

The sound exposures that they recorded instantaneous were 79 to 99 DBA with an equivalent continuous level. That's LEQ equivalent continuous level of 75 to 95 DBA with a mean of 85.5. Hey, look at that. It's right in that range of sound exposures for the ONHS study. Maybe slightly on the lower side, but you know, it's a pretty good representative sample.

68 exposures, half of them, just over half had notched audiograms impressively. All of the violinists had a 4kHz notch in their left ear because, well, that's where their sound exposure was.32 musicians had really good exposure history and great hearing threshold levels that correlated their hearing threshold levels, their audiograms correlated with their LEQ measures as in Mead and the Roysters took say the violin, the first chair violinist, and they took the second chair trombonist. And they looked at what their noise exposures were and they applied that noise exposure over the course of their working and they used the ANSI S3.44 standard to say, all right, if this person is exposed to 85.5 DBA for 25 years, what would their predicted hearing look like? Well, in 32 musicians they were able to correlate spot on that, hey, this violinist is getting say about 102dB on average. But for two hours a day we would predict the audiogram to look like X with some, some degree of noise notch.

And in fact that musician had very close match to what their predicted noise notch would be. Music damages hearing in a fashion maybe not identical to how occupational noise does, but it does it in a similar dose effect relationship.

Alright, so we've got through a lot of that background and I know that this takes a lot of time and attention to focus on. And I know it's dry and boring as can be. I don't know about you, I found my noise class to be a little bit challenging. I was the professor of my own noise class because I did directed

study on it. The background stuff can be really tedious, but boy, it sets us up now for saying, okay, so what do we do about it?

All right, so shifting gears now. We're halfway through this presentation today. Now we get to take all that background and apply it now to our patient, someone who's coming in, you know, they're a musician, they Fired their last audiologist and you know, they're going to come in and they're going to be a little bit defensive and belligerent and think that they know more than you do. Yep, been there. So what do we do about these, these interesting folks?

We gotta check them out, we gotta find out, well, what process here do we have? What kind of music induced hearing disorder is walking in the door? Alright, can we take care of this? Can we manage it in house? Or is there actually something going on here that we need to refer them out for further medical evaluation and management?

Just because they're a musician and they have tinnitus in their left ear and they're a drummer and the snare is right there. And so of course we think that they've got, you know, a left sided tinnitus from a sound exposure. That doesn't mean that they don't have an acoustic neuroma. Just because the musician has some hearing loss and they've been playing, you know, in a group and they're, they're doing some studio production. Just because they have some hearing loss doesn't mean that they can't have otosclerosis.

Musicians have acoustic neuromascular and otosclerosis and they have chemotherapy regimens and they have genetic hearing loss just as much as your average layperson. So we do need to be vigilant and see when do we need to make referral for medical eval and when do we manage this in house. And we're not just doing an audiogram and saying, here, stick a plug in it, let's move along. We have to evaluate their tinnitus reaction. We want to evaluate them for hyperacusis, we want to evaluate their diplocusis.

If that is part of their presenting symptoms, then we need to think about, let's prioritize. Do we address their permanent threshold shift? Do we address their hyperacusis, their diplocusis or their tinnitus? Obviously we're going to address all of what they present with. But if they show up saying my tinnitus is really driving me nuts and you say, oh, and hey look, you've got a mild to moderate sensorineural hearing loss.

So let's fit you with hearing aids. Yes, it's true, those hearing aids may well manage, help to manage their tinnitus because it increases their ambient background and it helps them, helps to take the edge off that tinnitus as being the most salient auditory signal. Yes, the hearing aids will help, but if you're looking to address Their hearing loss with hearing aids. And their primary concern, their chief complaint was tinnitus. We have a mismatch between what your priority is and what their priority is.

Now you can address their priority, their tinnitus, by fitting them with hearing aids. What you've done and how much it's going to cost them and your time with them may end up being exactly the same. But it's about the message that you convey to them, that you either win their trust or you lose it. Case in point, 59 year old trial attorney picked up the bass guitar four years prior. We don't have a previous audiogram for him, but it's one of these.

If it looks like a duck and it quacks like a duck, it's probably a duck. He has an asymmetric sensorineural hearing loss. Let's see. Left ear has a notch at 4K and 6K, it's down at 40 decibels. With this delightful recovery back up to 15 decibels.

At 8K, his right ear has more significant loss. And hey, look at that. You can see why I tested 6k, even though his 4k and his 8k thresholds were both at 55db. I tested 6k and lo and behold, we've got a 70db shift there. And it matches up so beautifully with his left ear.

Really steeply sloping loss.

Three weeks prior to seeing me, they had a really loud practice. He had already scheduled to come and see me to get some hearing protection because he knew that it was loud but this drove him in. So they had this really loud practice. And his crickets, he had a cricket like quality to his tinnitus. They got louder.

Notice he previously had tinnitus with a cricket sound, but it got louder. Okay. And this was the triggering event that brought him in. Okay. Had normal tympanograms, normal middle ear muscle reflexes, excellent word recognition scores bilaterally.

Okay, so normal attempts, normal reflexes, excellent word rec. He's not dizzy, he doesn't get headaches. He presents with no other otologic concerns that would say, hey, I really need to send you in to see an entire. Now, why the asymmetry? Well, he's the bassist and oftentimes the bassist and the drummer are positioned in exactly the same spot on one position.

The lead guitarist is in the other position. Rhythm guitarist basically sits back a little bit and they don't get to move much. And it's the vocalist, the frontman that they're the one that's really the entertainer. They're the One moving around and the rest of the band is kind of backing them up. I've played both.

I'm actually really happy being a rhythm guitarist in a world of guitarists. Be the bassist. Why the asymmetry? It's because this guy stood to the left hand side of the drummer in a small practice space that was drywall all around, highly reverberant space that was small. And the drummer is immediately on his right, like he's almost on top of the drummer.

And so here he is, he's playing his bass. Drummer's like hitting his snare. It's over. It's just on his right hand side. His head is acting like a baffle.

It's a little barrier. His left ear is slightly protected where his right ear is not because a lot of the high frequency sound hits the side of his head and bounces off. You have a very. You have a good 7 decibel decrease in what your sound exposures are from right ear versus left ear if the exposure is over on the right hand side. So yes, I identified the asymmetry.

I discussed it with him and I said, so technically, because there's an asymmetry here in the hearing loss. It may be something where an otolaryngologist might evaluate this and say, is there anything else going on here, such as a space occupying lesion, as in a benign growth on one of the auditory nerves? I said, the grand scheme here though is that anyone looking at your exposures would say you have a noise notch in both ears and the asymmetry correlates perfectly with what you just described. I feel incredibly confident that this guy not going to see an ENT is perfectly okay. Yes, I documented that I had the conversation with him.

But the chances of him having an undiagnosed acoustic neuroma is I would call zero. As close to zero as you can come.

I fit him with hearing aids.

Custom tips on his ric hearing aids. The largest vent you could have. In fact, it was a wide open like essentially there was no dome to had a little lock that went across the cruse of the helix up into the. The simba concha. So up in the highest.

Up in that highest little part of the ear. I'd have to show you a little picture. I'll just mention Starkey made the custom tip for me. It was awesome. And so I had a tinnitus program in there just to take the edge off.

And I engaged with this guy in CBT for demystifying the tinnitus and helping him to reframe it. And he did great. He did really, really well. He's still a patient of mine, but I only see him about once every two years. Okay, here's another really interesting individual.

And this. Actually, I saw this guy 14 years ago. This was two years after I got my PhD and I was in my postdoc at Boston Children's Hospital, Harvard Medical School.

Yep, it was interesting.

I didn't know enough at the time. I would have done quite a few more things with this guy. But the story is, at least to me, highly illustrative. 39 year old. He had been a semi pro musician for 20 years.

By day, he was a radiology technician, but he practiced about three days out of the week, maybe four days out of the week. He had chronic subjective tinnitus. He had seen three audiologists and four ENTs. They would test his hearing. Hearing is normal.

The sound is in your head. You're gonna have to learn how to live with it. Well, we had. He had normal tympanograms, he had excellent word recognition score. All these things, you know, we're like, well, look, your hearing is normal.

You know, you're just gonna have to learn how to live with it. That kind of message to him was one that actually sucked the hope right out of him. And he was using foam earplugs and shooter's muffs, as in like, you know, ear muffs during practice. This guy's the singer, guitarist, and he can't hear people in between songs and stuff. And yeah, he looked a little odd.

He did quit one of the bands. He was actually there making some good money, but he quit the band because the drummer was just too loud and the drummer couldn't play softer. So he was at. He had a

really significant emotional response. It was an anxiety response to his tinnitus.

And at the time, I hadn't been appropriately mentored yet in how to evaluate and address tinnitus. Thank goodness for folks at Oregon Health Sciences University and University of California, San Francisco, who mentored me in some of the work that I did on tinnitus since. So that said, here's this gentleman's audiogram when I tested him, and you can see he has normal hearing sensitivity right across the board. Maybe the tiniest little sniff of a notch at 6,000Hz in the right ear. Certainly not diagnostic of anything.

And here's his otoacoustic emissions. So this guy has normal, fairly robust emissions right up through about 5,000 hertz, and then at about 6,000 hertz and above, he has no emissions. So it's on both sides too. Both right ear and left ear. Really obvious.

Okay. And so I showed him this and I said, well, right. Your hearing sensitivity, your ability to detect soft sound is in fact normal. However, this other test that I did that does look at the integrity of some of these cells that are deep inside and are sensitive to noise exposure. It actually shows that about 6,000 hertz and up, you have just some really significant injury here.

And the fact that there was a diagnostic test that showed something immediately lifted this weight off of his back. He said, see, I'm not crazy. And the actual, the diagnostic process actually just showing that there was something gave him such relief that he rejoined that really loud band again. He was using 25 decibel attenuators. Er 25.

Even though it was a little more than frankly, he needed ER25 musicians plugs. And he was right back at it. He did practice really good hearing hygiene. He took a lot of quiet breaks. He was doing great with it.

But his reaction to all of this was just much, much better.

So what do I do with my musicians? So this is the full diagnostic battery. If you don't have time or you need to extend this out over two different sessions, yes you can. And if you cut something here that is at your discretion, I'm not suggesting you're doing a bad job. I'm just noting this is what I do.

Comprehensive audiometry. Do your word recognition scores. Do bone. There's reason to do bone even down at 250 hertz. If your audiometer is calibrated for it.

Do bone at 250. So there's some suggestion that doing extended high frequency audiometry so above 9,000 Hz. Colleen Leperell at UT Dallas Calier, she published a paper in 2013 that showed a significant difference in headphone users who used headphones and did not use headphones. Those who used headphones did have poor extended high frequencies than did those who didn't use headphones. Interesting stuff.

I myself have used it before, but I don't routinely. Just so that's a plus minus on doing extended high frequencies. You can do tempsometry, of course you tympanometry because, well, it's part of the diagnostic process, the diagnostic battery. You may or may not do middle ear muscle reflexes. There's a reason why it's really good to do them and there's a reason why it's really good not to do them.

And we'll talk about that with the hyperacusis evaluation. I do distortion product otoacoustic emissions. You can do transients, whatever. I like to do a nice tight sampling. It's four frequencies per octave, so it's a little bit more than the typical one or two frequencies per octave and I extend up to 10,000 hertz.

So if you measure, if you do those, you may find some interesting little shifts or reduction in the otoacoustic emission. And as I noted in that 39 year old singer guitarist who had the really bad tinnitus but a normal audiogram that was really diagnostic and in fact the process of that diagnosis was

therapeutic to him. So I recommend doing this at least annually or you do it as needed to evaluate for temporary threshold shift. I say annually because, well, the OSHA regulation says that sound exposed people are supposed to be tested annually and evaluate them for a shift from their baseline. Musicians are sound exposed people.

If this is what they do for work, we follow the same rule. It's once a year or again as needed to evaluate their temporary threshold shift if that is part of their chief complaint.

If tinnitus is their chief complaint, I administer the Tinnitus Functional Index. I used to do the Tinnitus Reaction questionnaire. That was my go to for a really long time and I do still like it. However, the new standard, and this is a consensus work from Mary Meikle and a whole lot of other brilliant tinnitus clinicians and researchers, is the Tinnitus Functional Index. It's a great tool if the response, if this self administered questionnaire, if the person meets the criterion for being clinically significant, which is on the tinnitus functional index, if it's a 25 global score, 25 or more, they're going to need some help with their tinnitus.

If they got a global score of 50. Oh yeah, you've got someone who needs help with their tinnitus and frankly you should address their tinnitus before you address a hearing loss.

If it's a tinnitus reaction questionnaire, the clinically significant criterion is a 17. Again, I found those to be highly consistent with one another. And so I've shifted over to using the tfi. I do it at the intake and typically at the end of therapy, but sometimes we'll do it in between as an interim. Just got to be careful not to do it so consistently that they're anticipating what their last answer was.

I generally do a minimum masking level. So put in speech noise for instance. Speech noise and pink noise are very similar. It's just general, broad bound, slightly low frequency weighted sound and I raise that up and have the person push the button when their tinnitus goes away. I say it that way, push the

button when your tinnitus goes away.

That gives them a response, something that they're used to pushing the button when they hear the beep. Now I say push the button when you no longer hear your tinnitus. And I document for each ear separately at what level were we able to achieve masking. Like I don't hear my tinnitus now for some people you have to raise that level up really high and that may make them uncomfortable. And in that point I make a note of the fact that I could not achieve masking.

That's an important diagnostic component to this. So you document it, you get what it is. They may actually be shocked how soft that level is. That may be only like 23, 24 decibels of speech shaped noise to mask their tinnitus. That may shock them and frankly it may give them a really wonderful sense of control that, wow, I don't have that really annoying tinnitus sound in my ears.

I'm plus minus on measuring their on doing a loudness match or a pitch match or on whether or not they have residual inhibition from their tinnitus. There are specific reasons to do a loudness match and a pitch match. There are some FDA cleared tinnitus therapy products that are out there that I've explored a little bit. And there may be reason to consider somebody if they're a candidate for using some of these tinnitus therapy systems measuring whether or not they have residual inhibition. I've not found it necessarily to be diagnostic or predictive of them being able to get better.

But I have found that residual inhibition is at least nice to know, but it's not something that you prioritize that over doing say the tinnitus functional index. And absolutely, each time at this initial evaluation for tinnitus, I provide informational counseling which takes on the flavor of here's what tinnitus is and here's what tinnitus is not. It is not a hair cell dying. Tinnitus is not a disease that's happening right now. It's actually circuit noise in your auditory system that is a reflection of a past injury and noting that this was something that happened in the past and it's actually not something that's happening here in the present.

You're just perceiving it in an ongoing fashion because it's a consequence. And that consequence is it's a circuit note. And I use that to basically neutralize the significance of the tinnitus that it's just there. It's like the refrigerator hum. It's like the feeling of the shoes on your feet.

These are things that your brain tells you is not there. Like it's there, but it's of no consequence. And unfortunately, where the tinnitus is concerned, your brain has assigned an inappropriate significance to it. We'll talk about how to demystify in this in the talk next week. And about the tinnitus therapy components of this.

This is part of that cognitive behavioral therapy. But this is. I give this initial insight into it. This partly helps to establish that trust. Now again, this doesn't mean that I don't fit them with hearing aids, but it means that my approach is first addressing their chief complaint.

So the evaluation process for loudness tolerance complaint. Okay, so we're thinking on the hyperacoustis side. This is interesting. This is very interesting. This is hard.

I would much rather evaluate somebody for tinnitus than evaluate them for hyperacusis. The reason is because where tinnitus is an annoying sound and it does take on some of the components of pain, like some of the. It's analogous to chronic pain in people who have back pain, etc. Hyperacusis is actual pain. And these are people who are really difficult to reach sometimes.

But here's a really important and interesting like little thing to parse out. Is the person feeling a pain or are they anticipating feeling a pain but not really feeling pain? And so they're guarding against that louder, like a louder sound. So if you measure their loudness, discomfort levels, UCLs, LDLs, and you say, okay, push the button when that level like hits, hits a threshold of ouch or push that button when if, Let me see if I can use the words that I use with the patient when instructing them. I'm going to play this

sound and I'm going to increase it just a little bit at a time.

And you're going to be in control with whether or not I stop the sound altogether. You're in control. And that's part of that establishing trust. You're in control of this. I am not going to present a sound that's too loud to you.

I know that I'm not going to damage your hearing, but I need to palpate it, I need to touch it. You know how a physician touches something that like if you break an arm, they're checking to see just where is that pain, where is it happening? And so they just gently palpate. They touch it. That's what we're doing with this sound here, we're going to palpate that.

And you're going to let me know when I shouldn't make any more sound. I'm going to let you're going to let me know by pushing that button when I shouldn't make any more sound. And so I do, I raise up and sometimes it's shocking just how high they let me go. Sometimes they go up to a level like say it's only like 65, 66, 67 decibels and they push the button, I drop back down, I go to a different frequency and I do the same thing. I come back and I check to see do they still answer at that same 66, 67, 68 decibels.

If they do, hey, they're pretty consistent. And I mark that. Now, once you've established trust, can that patient tolerate you doing ipsilateral acoustic reflexes? Do frequency specific? 500Hz, 1000Hz, 2000Hz.

I don't do 4000Hz. I find that people with normal hearing sensitivity and normal reflexes have no response at 4k anyway. It's just annoying. So what 501 and 2000hz and check to see at what level does the person have an acoustic reflex.

If they have what I've at least myself, I've not heard this published anywhere else, but if they have an organic hyperacusis as opposed to like a cognitive, a pseudo organic hyperacusis, it's not that they're

faking, it's just that their ear is not responding and reacting to a sound that is loud and you get a reflex. This is them cognitively saying, oh, I'm scared. If a person has an organic hyperacusis, you will get an acoustic reflex of around 70, 75 decibels. You may in fact get a reflex at 65 decibels. And if that correlates ballpark to their loudness discomfort level, you've got somebody who has an organic hyperacusis.

This is not a matter of them just being afraid of loud sound. This is a matter of them actually their ear is rejecting sound that's getting that loud and it is a result of an injury, typically an acoustic trauma, and you need to manage them appropriately. Again, that management. I'm going to get into it next week, but this is how you're going to evaluate. I do DPOAEs to measure.

Hey, is there reduced otoacoustic emissions in addition to either normal or abnormal acoustic reflexes, in addition to reduced LDLs? And you can take that tinnitus functional index and change the word has your tinnitus, blah blah, blah. You can change it and say has your sound intolerance resulted in difficulty achieving sleep? Has it resulted in avoiding noisy situations? 0% of the time, 100% of the time.

And I find it highly illustrative if a person is guarding and they're just afraid of the loud sound, opposed to their ears literally rejecting the loud sound that guarding may be because they have tinnitus and they're afraid of a loud sound exacerbating their tinnitus. They don't have hyperacusis, they are just guarding against an exacerbation of their, of their tinnitus. If they have hyperacusis and they have tinnitus and they're. And you do reflexes, they let you do you, you do reflexes. You start at 60 decibels, then do 65, then do 70.

See how they're doing, See if they tolerate higher. You're going to, you should be able to tease out whether it's an organic or a pseudo organic hyperacusis. Alright, last thing here. And this is, this is challenging. Again, this is just what I did this morning with this gentleman who presented with a distortion in his right ear after an acoustic trauma, pitch perception problem or a distortion complaint.

I talked a little bit about the history was pretty obvious that yep, this correlated well with this event and that it is in fact level specific, you know, average level speech doesn't do it. But then when he plays in the, in the group again. Oh yeah, there it is, there's that crackle and it just sounds nasty. You may get poor speech and noise results or you may get poor word recognition score scores. This is where when you get poor speech and noise, poor word recognition, you get absent acoustic reflexes.

And especially if you get asymmetry in the hearing loss. That's where I make medical referral because that distortion, that makes me a little uncomfortable that maybe something is going on here, that this person needs some imaging just to rule out possibility of a benign growth on that, on that nerve. However, let's say we've ruled out space occupying lesion or other active disease process like Menieres for instance. You can get this with Menieres. Let's pull out a signal generator and a tuner and let's learn a little something.

So this is for your benefit. This is in the handout Here is an 88 key piano laid out from the left hand side which is the very low pitch. So sound okay, up through very high pitched sound. And I have listed out here in ascending order of fundamental frequency, the first key on the piano, the first black key, second white key on the piano, all the way up through key 87, key 88. The fundamental frequency of the first key on the piano is 27.5 hertz.

That is low. Obviously, for a lot of us, we really only hear the overtones. We actually don't even hear the fundamental. For the 88th key on the piano, the fundamental frequency is 4186. The first harmonic to that is about 8400 Hz.

The first harmonic. There's a second harmonic there which is at 12,800 hertz. Or, sorry, 12,600 hertz. Yeah. Talk about needing some high frequency hearing here.

So this, these are the fundamental frequencies. And so here is A above middle C. It's key number 49. Fundamental frequency is 440 hertz. Look at all of this. Really good low frequency representation from A above.

So here's middle C. Here's A above middle C going all the way down. Okay, how's there? Are they able to resolve each of those? Like actually resolve the pitch? Well, here's what I do.

I get out a signal generator. This is from an app. This app is called Audio Tools. It's just an app, an iOS or it's an Android app that you can get. And I hook it up to a speaker and I play a tone.

That tone is.

The fundamental frequency. Let's see. Let me go back one. So 1320 is what I put on this one. Let's see.

1320. So that's about key number 68 slightly off. So it'd be a little bit off. Tune key number 68. And I asked them, make an adjustment in the wheel here.

And we measure. Hey, where did that come out? All right, is it at 440 hertz? Sorry? Actually this would be like an E. Is it an a?

Here's at 880 hertz. That's the first octave above A. Above middle C. Do they hear it as that note or do they have to adjust the frequency a little bit? Do they adjust at 20 Hz? Do they adjust at 30 Hz?

Or can they not hear the difference between say 880 and 920? If they don't hear the difference between the two of them, then they essentially have a really broadened auditory filter. We remember this, that your auditory filters, you're supposed to have really nice sharp auditory filters. It's part of what your

outer hair cells do for you is give this fine pitch rec, this fine frequency discrimination. If they can't hear the difference between those two, you've at least characterized their diplocusis.

It frames it. And you know, there's not a lot to do about it, in all honesty. But what you can do then is at least use this information to help them to understand the difference in what they are or are not giving up.

So I just talked about this a little bit. When to refer out? Well, if it's a hearing loss, sudden hearing loss, even if it's an acoustic trauma, you refer to otolaryngology. If it is an acoustic trauma, they can do inter tympanic steroid injections, try to get it back. Musicians do get sudden sensorineural hearing loss from a virus or from autoimmune stuff just the same as anybody else.

Unexplained asymmetry. Okay. In particular, if it does not look like a notch, that's where you refer out conductive component. Especially if you have abnormal tympanometry or elevated acoustic reflex thresholds. Yes.

Just as with anybody, you have conductive component to it. Refer out poor word recognition score. Especially if it's unilateral. Again, we're thinking about tumors. And if they have concomitant dizziness with intense sound, for instance, the tullio phenomena, loud sound on one side.

Hey, this is start and it makes them dizzy. This makes us think of a superior canal dehiscence. They get this just as anybody else would get it.

Okay. For tinnitus. When are we referring out? Well, you should ask the question when they come in and it's an important question to ask and you document the answer. So I know this is something that's causing a great deal of stress for you in your life, and I'm really glad that you're here.

This tells me you're taking this seriously. I'm taking this very seriously. So I have no reason to believe this. But I'm just going to ask because I really want to and I want to make sure that everything's going to be okay. Do you feel that there's any risk for you hurting yourself, doing anything to yourself or that you might do something to anybody else?

If they do, that's about the time you call their primary care physician. You call if you have a psychiatrist that you do work with, you run it by them and they may end up seeing them urgently. Worst case scenario, you call 911. Saving a person's life really, really, really is an incredibly important thing for us. To do.

I mean, I know we're not faced with it all that often, but tinnitus actually can kill you. Because there are people who have committed suicide from their tinnitus and feeling as though they can never, ever, ever get away from it. And it's the hopelessness that drives the depression that may put them into suicidal state. We're not asking them, well, are you going to kill yourself? This is where you have them have that trust that you've established with them.

And you say, is, is there any risk, do you feel that there's any risk that you might, you might hurt yourself? You don't say kill yourself, you say hurt yourself or that you might hurt somebody else. These are the important things that we do ask now as well. I'm not, I am not a psychologist. I'm not a licensed psychologist.

I am not a psychiatrist. I do not diagnose anxiety. I do not diagnose depression. However, I can administer a screening questionnaire and I have. But just as to general layperson, does this person seem anxious?

Does this person seem depressed? Do you feel that it's appropriate for them to be evaluated by a psychologist or a psychiatrist? Yeah, if they're getting tinnitus therapy from you, typically speaking, I'd

like for them to at least have an evaluation by a psychologist just for an overarching like, hey, just to check in. How about their sleep issues? Do they have really horrible sleep issues that they in fact, actually would really benefit from seeing a sleep medicine specialist?

If they are not sleeping, their ability to cope with, with anything is terrible. So that's really important for us to focus on. If they have unexplained unilateral tinnitus, you know, just like before, if they have concomitant dizziness, dizziness with unilateral tinnitus, yeah, that's, that's a warning sign for a tumor. Poor word recognition on that affected side. Elevated or absent acoustic reflex thresholds on that affected side.

Those are all reasons, of course, for making medical referral hyperacusis. Almost exactly the same questions.

Okay, so now prioritizing this, why did they come in? Okay. Tinnitus is almost always the reason. If it's not tinnitus, then hyperacusis. Okay?

If they have hyperacusis and tinnitus, you prioritize the hyperacusis. You fit with hearing protection devices. It's a standard recommendation. If they are a musician, if they are music exposed, they need to manage their sound exposures. And I always recommend custom and it's not Because I can make more money off of it.

It is because it will actually work. And the whole point in all of this that I really get at, and I've said it before, treat the patient, not the audiogram. So I want to make sure that we have enough time on these. I'm just going to barrel ahead on a couple of them and I'm going to stick around a minute longer or a few minutes longer. So hearing protection devices, I talked about the whole, you know, why would you fit custom to them?

Multiple reasons. And I'm sure you all, I am literally preaching to the choir on this. But these are important components for you to consider. Why are custom hearing protection devices better? The sound quality will be better.

And I'm going to do some sound simulations now for you to hear this and think about it. The consistency of how well it fits in your ear matters more than the absolute sound isolation you get. It's the predictability of protection that matters more. Rick Neitzel published a paper in 2004 that looked at the published noise reduction rating on the hearing protection device label the NRR relative to the individual's personal attenuation rating. So they literally did a hearing test with the ear open and then with the earplug in place.

That gives you your par. If that noise reduction rating is correct, the PAR should match your nrr. It turns out that for custom, it was really close all the time. If it was non custom, their personal attenuation rating was all over the map and it didn't come close to matching the noise reduction rating. And that's not to mention, y', all, that if it's not comfortable, unlikely that they're actually going to use it.

And I know that foam earplugs can be comfortable. You know what, they get itchy and sweaty eventually and it's just not as comfortable. So just for sake of getting this and hearing it and like intimately understanding it ourselves, I'm going to play a Blink 182 clip. So this is like a 10 second clip from a Blink 182 concert that I was at. And so I have the levels.

They're not nearly as loud as they were at the conference, but so just bear in mind I'm going to play some really loud music. So if you're listening over headphones, just be ready to get, you know, hold on to them. All right, here we go.

Okay, so now I'm going to play that same sound through deeply fitted foam earplugs. All right, so this is stuck in as deep as you're supposed to where the person opens up their ear. You roll that foam plug

down, you stick it in the ear and this gives you around say, 28 decibels of sound isolation. Do we actually need that?

Okay, so believe it or not, if you listen to the two of them side by side and you'll go back on the recorded session and do that, it sounds like you're outside of the concert venue. Now let's take what most people do and that's this shallow fitting where you just barely put it in. And it actually attenuates high frequencies a lot, like about 20, 25, 30 decibels. But attenuates low frequencies almost not at all because you have a slit leak that the sound passes right on. The low frequencies pass right on by that poorly fitting plug, but the high frequencies hit it and bounce right off.

So this is what the consequence.

So now let's go to an ER20. Now it's a non custom headphone or sorry, headphone, it's a non custom earplug, but it's intended that if you place it deeply enough in the ear and you get a good seal, you should get a better, better frequency response. Let's listen.

And now finally, let's see. Is the custom earplug any better? And so that, you know, I've processed that open unprotected ear, I've processed all of that sound file according to the frequency response in my ear of these different earplugs. So this is what I actually hear when I put my musician's earplug in.

And that's relative to the open, Not that different. I'm just going to stop there because again, we're running really close to the end of time and I want to touch on these pieces. But it is possible, folks, for us to prescriptively fit our hearing protection devices. All right, so the amount of time that we can be exposed to a loud sound, for instance, say A sound over 85 decibels is determined by this equation. Eight hour exposure with an exposure level, say 85 minus the maximum you're allowed to be exposed, divided by our exchange rate.

So 3 decibels or 5 decibels. And our overall noise dose, which is determined in a percentage, is the exposure time divided by the allowable time. This will make sense when I give an example.

Your allowable exposure time to 85 decibels is 480 minutes. 90 decibels is 151 minutes. This is according to the 85 DBA for 3 DB exchange rate or 100 decibels for 15 minutes versus here, the 90 decibels with 5 DB trading ratio, 100 decibels for 120 minutes. I get these numbers this time to maximum exposure. I get that from these, from this top equation here, this.

So now theoretically, if a person is exposed to 97 decibels for eight hours a day, say this is this person's chosen listening level with their headphones or, you know, let's say this is their 8 hour exposure level and they need to be able to hear themselves. Do we need to fit them with like a like full solid earplug? That, that 29. Sorry, that. Yeah, that 39 year old musician who was using the foam earplugs and the shooter's earmuffs over top of it.

Did he need that much protection or did he need less? This is actually one of the quiz questions. So his noise dose is his exposure time 8 hours divided by. Sorry. Actually this is the time 8 hours divided by 2 raised to the 97, minus 85 divided by 3.

This, that's 12 divided by 3, which is 4. So 2 raised to the 4, that's here 2 raised to the 4. So that's 8 divided by 16 or 30 minutes. You're allowed to be exposed to 97 decibels for 30 minutes. His actual exposure time, 8 hours.

At least in this hypothetical scenario, his noise dose 8 hours divided by 0.5 hours, that's 16, as in that's 16 times your allowable or 1,600%. If we gave him an ER 15 musician's earplug, then his exposure is 97 minus 15 or 88 minus 85 divided by 3. So it's 3 divided by 3. It's actually 2 actually, sorry, 82 minus 85 which is minus 3, minus 3 divided by 3 is negative 1, 2 raised to the negative 1 is 0.5. So 8 divided by 0.5 is 16 hours.

His exposure is 8 hours. If he is in 97 decibels of noise for 8 hours, but he's using an ER, 15 plug, he's getting a 50% noise dose briefly, just to note, just because we say that they're flat doesn't mean that they are. If I take a probe microphone and I place it in the ear and I play an MPO swept tone, just as we would with a hearing aid and I measure that swept tone and then I do it again with the earplug in place. Green is open ear, that's that nice open ear response. And purple is with a very well fitted Earplug in place.

Look at that, it's following perfectly. And if I went over to the table, I would see across frequencies. I'm getting 11 to 22 decibels of sound isolation and I've got a standard deviation of 3.5. Average of 15.3. It's pretty good.

Just note, this is good, this is bad. This is poorly fitted earplug that's not extended deeply enough down the canal and you actually have a slit leak that goes right across. One might wonder, and here's another quiz question.

What do you do to take that probe microphone and keep it from causing a slit leak when you're trying to do this measure? You take OTOEZ or whatever, water based lubricant and you lubricate the stuffing out of it and make sure you basically plug up all around it. And that way you get the best you can. And if you still get this kind of response, then you know that you don't have adequate attenuation in the low frequencies. And this ear plug is not going to sound flat to that highly trained ear.

Alright folks, I know I'm a little bit over, but I'm going to take a little bit and I apologize, you can give me terrible reviews later. Custom in ear monitors, why would we use them? Number one is for improved signal to noise ratio. Number two is for better sound quality. The levels on the stage are about 105 decibels.

If we were to say give them an ER15, then their level is still 90 decibels. But the person still wants to hear more of themselves. And so they start to turn their amp up a little, turn their amp up a little bit, which causes the drummer to play harder, which causes the other people to play harder and louder. And so now all of a sudden instead of 105, you now have on stage levels that under the protector is 90. You now have levels that are around 110, 112.

And the level under the protector is now about 97.

The idea of putting a monitor in means that you can actually reduce the stage levels. You can reduce the stage levels instead of it being about 105 on stage, the drummer doesn't play is the only sound source there. You don't have wedge speakers blasting back up at the individuals, okay? And so you can actually reduce the stage levels and you maintain a really good signal noise ratio. The one risk with this is consider these are very powerful headphones.

That's what they are is a headphone. And they can damage their hearing. And so you need to teach Them and you fit them with these. So you're liable for their noise induced hearing loss if they do it. Monitor at the lowest level you can, and frankly, you're in really good shape if you were to do probe microphone measures and advise them what level they can turn their monitors up to before they start doing damage.

One way to do this, so just examples is you can do a custom sleeve on a non custom in ear monitor. You can go with a flat full custom in ear monitor. You might get about the same, if not better sound isolation than what you get here. Here's one way that you can monitor. What level are they actually listening to?

This is a company called Sensaphonics out of Chicago. I do love them, I use them quite a lot, but I don't endorse them per se.

If you plug this into the DB check and you plug this into their belt pack or into the stage, the sound board, then you're actually going to get an inline sound level meter and it'll report out how many minutes can you be exposed according to the NIOSH damage risk criteria or according to the OSHA damage risk criterion. And this way the person can say, well, wait, I'm listening at 95. My practice is two hours. That's too loud. I'm going to reduce my level finally.

And I know I went over a few minutes. Thank you all. Do you do a jaw open or jaw closed when you fit them with their custom hearing protection? Well, this is really important stuff. Here's some images that I got from Lantos Technologies where we did an ear mold impression on somebody with the mouth closed and did it again with the mouth closed.

And it's a heat map. So wherever it goes green to red, this is where there's some differences from one ear mold impression to the next. And where it's blue, there's no. There's like tiny, tiny, tiny differences in this heat map. One half of a millimeter is green.

Okay, so these little areas that are green, that means you were off. I was off by about a half millimeter right through this region at the front wall of the ear canal. In the first bend of the canal, one impression to the next, there was no difference. When I had the person open their mouth and I did a third ear mold impression with their mouth open. What you see, see this range right here?

It's over a millimeter difference. That is enough to cause this slit leak. So how do you deal with that? Well, you do the ear mold impression while they're playing their instrument that puts their jaw in the position and their ear canal in the position where the device will be under use as in the earplug is in use. I'm going to show you all something that someday may end up being commercial.

It is not yet commercial, but Lydia Gregorette, who's the director of translational research at Lantos Technologies, is doing a presentation next AAA or we hope she's going to do a presentation next AAA on the dynamic shape change of the ear canal. I'm going to show you how my ear canal changes shape when I open and close my mouth.

Opening and closing. And again, this is a heat map. I'm going to pull up my arrow. See right there? See this region right in front?

It's actually where I clench my jaw.

Clench. I get a big shift right in there. Thank you very much, Kim. That's awesome, Christy. Thank you.

So that's where that shape change can occur. At some point down the road, it should be possible to have a way to measure that ear canal while they are playing. Okay, so I just have one last slide folks. And again, thank you so much for sticking around with me. So the big picture in all of this is we have sound exposures can cause a music induced hearing injury.

Music induced hearing disorder. The injury is something that happened. The disorder is the ongoing consequence to it. It is not a hearing loss per se because it's not just hearing. Okay.

We also have.

We have these different processes for diagnosing these disorders and we really, because it's easy for us to. We focus in on, on that audiogram. Okay. Don't necessarily treat only on the audiogram. The audiogram is a tool and it's one tool to assess four different things that they may come in with.

So that helps us to understand, but it isn't the full explanation. Tinnitus questionnaires, detailed case history helps to elucidate. I know I was a little bit short on my time here and I apologize for that. But I really want you to take home that a custom hearing protection device and or custom in ear monitors are very appropriate ways to address their risk. It's not the only way to address their risk.

Thank you, Dr. Fligor for that excellent presentation. No worries on the time. Dr. Fleigar. If you wanted to give any last comments, we'll go ahead and close out the classroom for this afternoon. All right, well, sounds good folks.

I would just encourage you tune in next time you think. I had a lot of stuff to say here today. I am going to really hit it hard right into the tinnitus therapy, hyperacoustis therapy, and hearing aid fittings. I am not going to be getting into cochlear implant mapping because I am not a cochlear implant specialist. I have touched it just a tiny bit under careful mentoring.

So, no, unfortunately, I'm not going to go into cochlear implants. But the rest of these pieces, I will. I love this patient population and I hope you all really start to enjoy them and say, you know what? Bring that musician into clinic. They value their hearing as much as I value my hearing, more so than so many of my other patients.

So they are as motivated and they're highly educated. And so just bring them in. Thank you, Dr. Fligor. We hope to see everyone in part two next week. Bye.

Bye.