Audiology, Anywhere: Hearing Assessment Outside the Booth

Presenter: James W. Hall III, PhD

It is my honor to introduce our webinar today titled Audiology Hearing Assessment Outside the Booth. Our presenter today is Dr. James Hall. Dr. Hall is an internationally recognized audiologist with more than 50 years of clinical teaching, research and administrative experience. Dr. Hall now holds an academic appointment as a professor part time in the Osborne College of Audiology Salus at Drexel University where he teaches international graduate audiology students. Please read more about our presenter in the handout and at this time I'm turning it over to Dr. Hall.

Thank you very much, Anna. Well, it's always a pleasure to be here and to give a webinar. I want to first move through a few slides of preliminary information. These are the disclosures and I you'll see them here. Of course, I'm paid for my teaching at Salus University.

I want to point out that although the learning event doesn't focus on any specific product, I will be talking about one product more than the rest. But I have no financial relationship with with any of these companies. These are limitations and risks which you can all review at your leisure and the learning outcomes at which I'm quite sure you will find very logical. And you'll have this information. You'll learn what I'm posting here certainly at the end of this webinar.

So let's get started. This is the time ordered agenda. I'm going to begin with a little introduction. I can't promise you it'll be only a five minute introduction. It may go a minute or two more, but we'll certainly leave time at the end for questions.

The second section of this presentation, this webinar, I'll really focus on why it's so important to monitor ambient noise whenever hearing is being assessed, particularly hearing thresholds are being assessed. And then I'll talk about some clinical instrumentation, not just one type, but several different brands of audiometers and devices that can be used for hearing assessment outside of a sound booth. And then I'm going to focus in the last section of my presentation on some of the research findings that I've been collecting and analyzing for a project that I've been involved in where we actually conducted

ambient noise monitoring with a large number of participants. And as I said, we'll definitely have time at the end for questions and answers. So feel free to be asking your questions as we go through the presentation and then I'll be ready to answer.

Answer them at the end. Well, let me start out by talking a little bit about our beloved sound booths, and I'm certainly not going to say anything in this presentation that would detract from the importance of a sound booth. We all have memories. Probably most of you have memory of the first time you walked into a sound booth and the unusual sensation that you experience when the door was closed. It.

Sound booths have been around almost as long as audiology, certainly for at least 100 years. And there, when you think of audiology and you think of an audiology clinic, almost always the first thing you think about is the sound booth. This photograph shows me in years when my hair was not gray back in the. Sometime in the 1990s, probably 1994 or 5, when I was at Vanderbilt University. The slide is dated.

You can look at the left and see the computer and realize we've come a long way since then. Now, most of us spend a lot of time in the sound booth. And I knew that it was a lot of time, but I didn't know quite how much. So I did some calculations, I did some math, and this is assuming that you're in a setup. And I'll show you some designs for sound booths or some configurations in a moment.

But imagine that the patient's in a sound booth, but you're in the control room, which is also a sound booth right next door. And so you're in a sound booth. Let's just say you've got a light clinical schedule, four hours a day. You've got a whole month for vacation, hopefully paid vacation. So you're only working 48 weeks a year, and you do the total.

And most of you would be surprised to learn that you've spent more than four years of your life in a sound booth, probably as much time in a sound booth as you have with your family. Now, we all have

funny sound booth stories. I could go. I mean, if you get a bunch of audiologists around, maybe sitting at a bar, there'll be hilarious stories. Some are not so funny.

I've had medical emergencies in sound booths. I've had older, very old patients, elderly patients, and of course, they seemed very old when I was younger, who almost didn't want to go into the vault. They called it a vault, thinking they'd never come out. And then, of course, we from time to time deal with patients who have a claustrophobic streak, and it's really a struggle to get them in the sound booth. Then, of course, there are reverent sound booth references, at least in my generation.

So, for example, you might say, hey, I heard that Joe died. Yep, yep, Joe's gone to the big sound booth in the sky or I, I, I think, I guess Susan passed away. I thought I heard something about that. Yep, she's hung up her earphones for the final time. So we.

Sound booth is a big part of an audiologist's life. And I'm going to explain and provide the rationale in this presentation for why sound booth, although they're very important, are not always necessary.

One problem with sound booths, as you know, is a big problem, literally is they're very large and they're very heavy and they're very expensive. So the footprint of a, of a typical sound booth is, is, is so big that obviously it's not going to be moved. They're non portable. Once they are in place, they stay wherever they are and they're so heavy that a large sound booth weighs a ton and a half. And in the early years of my career, a architect, when you're trying to build a clinic, would always question whether or not the floor of the building or the structure of the building could support the sound booth.

And many back in the 60s, 70s and even the 80s, most audiology clinics were in basements, literally in basements of hospitals or buildings where there were no floors underneath that could be damaged if the sound booth went through the floor. Ventilation is another problem. You've got to have air circulating, but that creates noise, particularly if there's a fan. I've always insisted that when I install a

sound booth or I have it installed, that the ventilation system for the sound booth is tied into the air conditioning and heating system, the insert and the return and all for the actual ventilation system for the building. But even then, sometimes it gets very warm in the sound booth, particularly with the door closed, if it's a really tight seal.

And then we really began to realize during COVID that the air doesn't circulate very much in a sound booth. It never was an obvious problem before. But many manufacturers, reps and engineers began to realize that if you were trying to constantly keep people safe with a well ventilated setting, sometimes you might only be able to test one or two patients in the sound booth due to risk of COVID during a day because the rest of the time the air wouldn't be adequately pure. And of course the cost is quite substantial. And sometimes it's the biggest investment in audiology clinic.

And then you and I, I mean, we just can't put together a sound booth. Obviously it takes a very, very specialized crew. That's an expense and the installation's hard, but the deinstallation is even harder. I'VE been contacted by people over the years as Director of Audiology with a plea, if you want a sound booth, we'll give it to you. So I said, well, what's the catch?

Well, the catch is you have to actually come and deinstall it, take it apart and move it out. And that sometimes can be even more expensive than installing. And we're going to talk about some of the other limitations of sound booths in just a moment, the physical challenges. And also, of course, we're going to focus a lot on the ambient noise challenges of any sound treated environment. So some of the patient related challenges are here.

And again, I've served as Director of Audiology for well over 30 years and so I'm quite familiar with these challenges. First of all, there's a challenge with ADA compliance. Most sound booths, unless you design a clinic way in advance in a place where the build is not even built, or at least the concrete's not even poured for the floors, the sound booth almost always sits up on the floor. So that means you have

to step up to get into the sound booth. Because of course the sound booth has a floor that's just as thick as the walls and the ceiling.

And that means you need a ramp for wheelchair access, which is a recipe for accidents. And then if you're in a hospital setting, which I've always been, you need an oversized door. At least in one of the sound booths, you can get gurneys, which are beds on wheels, into the sound booth. Otherwise you're discriminating against patients who are not ambulatory. You're not testing them in the same high quality environment.

Then there's the risk management. And this has been a problem. I could tell you all kinds of stories about this as a director of patients. Some patients, they fall into the sound booth because they trip on the step. They don't realize it's there.

And sometimes the same patient falls out of the sound booth. So you have to have some kind of marking and signage. If you don't have a ramp, sometimes there's not enough room for a ramp or the ramp prevents the door from closing. And then tall patients have a tendency to bump their head coming in or out of the sound booth. So those are serious concerns, particularly in a clinic population where not everybody's healthy and not everybody's real ambulatory.

Then we've already talked about the anxiety, the claustrophobia, and if you only have one sound booth, many of you have been in this situation. In a busy clinic, there's a traffic jam with everybody trying to get into the sound booth for whatever they need to do there. So it's a very inefficient operation when you only have one or two sound booths, but you have many more patients who need to be evaluated. And then as I've already said, I've had medical emergencies occur in a sound booth, which is really a difficult situation for everybody involved. So these are all patient related challenges that you'll always have to deal with with a traditional sound booth.

All right, now move on to the rationale for ambient noise monitoring. Obviously, if we're performing pure tone audiometry, we need to be sure that a normal hearing person can hear intensity levels of down to zero db HL or even lower. Theoretically, they really you should be able to evaluate somebody's hearing even if their thresholds are minus 5 or minus 10 dB. So we're now going to review the rationale for why ambient noise monitoring can assure you that the test environment in which you're performing hearing test is adequately quiet. Now, I've got some questions throughout the presentation and here's question number one.

And be thinking about this. I'm sure most of you, even before this lecture, without this lecture, you could answer this question. Identify one important clinical application of automated pure tone audiometry outside of a sound booth. Think of populations, think of places where you could perform the assessment, think of who's actually performing the assessment. And we're going to.

You'll find that the answers to that question will pop up numerous times throughout the presentation. All right, well, here's the rationale for automated hearing assessment. Using some way to monitor ambient noise levels in the test environment. Well, the first big advantage, as you can imagine, is you have a lot more flexibility as to where you perform hearing assessments. Again, you're not limited to the one or two sound booths in the clinic.

So one minor modification would be you've got to imagine a clinic. You've got one sound booth, but you got a lot of other rooms in the clinic and they're all reasonably quiet, they're carpeted, they have sound attenuating ceiling tiles, etc. If you can perform hearing assessment using an automated technique and you can monitor ambient noise very carefully, you could theoretically perform hearing assessments anywhere in that clinic. So you could have two or three different rooms going simultaneously. Maybe one is a sound booth and maybe two are not.

Of course you can't move a sound booth, but you can move equipment. So if you have multiple sites, multiple clinics, or maybe a main clinic and some satellite, there's no reason why you Couldn't keep your equipment, your autom device, your ambient noise monitoring equipment and software in the clinic some days, but other days use the traditional clinic with the sound booth for some patients, but you could actually have clinics in other locations at the same time because you don't need a sound booth in those other locations. And then of course, with the automation, the automated hearing assessment option. Now not only can you perform the assessment, hearing assessment in different locations, but you don't even need to be there as the audiologist. You can train a facilitator, you can train a technician or an assistant or some other personnel, maybe a nurse, to perform valid, perfectly accurate, high quality hearing assessment with air conduction, bone conduction if necessary, even speech audiometry, and do all of that in a well documented quiet environment anywhere you want.

It could be in a public school if you wanted to go perform actual diagnostic hearing assessments there or have someone else do it, maybe an aide in the school or maybe the speech pathologist using an automated device. It could be done in primary care, physician clinics, pediatricians clinics or family practice. Could be in va. And I'm going to focus in my data presentation toward the end about performing automated hearing assessment and monitoring ambient noise during that assessment in VA outpatient clinics, Veterans Administration outpatient clinics. But any outpatient medical clinic would be a potential location, industrial settings, going to a company and maybe doing a full audiologic assessment or somebody there might on people who have not met the OSHA requirements, for example, for hearing in a noisy setting. Or you could take it to a nursing facility, a skilled nursing facility, a nursing home or a prison anywhere.

There's no limit really.

Now, as we wrap up the rationale for automated screening with ambient noise monitoring, I'll just mention one other option this type of technology offers, and that is teleaudiology, that is the audiology applications of telehealth performing high quality hearing assessment anywhere in the world, literally anywhere in the world. It could be an urban setting where you have a population that has needs for hearing assessment but inability to be transported, or there's too much of a financial burden to have them come to a clinic. It could be in a very remote or rural location where there are no audiologists anywhere near. Or it could be I'm performing or overseeing automated hearing assessment and I live in the state of Maine in the United States, but the patient could be anywhere in the world. So as we think about using automated devices and documenting the sound levels where the testing is being done, you want to think big.

Think about the opportunities that that offers to totally extend the reach of audiologists and sometimes to places where there are no audiologists. Now here you see in this slide an article I wrote quite a few years ago with a good colleague of a friend of mine from South Africa, Devet Swanepoel, on teleauth health applications of audiology, where we talk about this and also a relatively recent book on the topic of teleaudiology where this topic is also discussed. Okay, well, we're really doing well on time, which is good. So now I'm going to actually talk about the clinical instrumentation that allows you to perform a hearing assessment outside of a, of a typical audiology clinical setting. And here's the next question for you.

So I'm going to just take a moment to read this and have you ponder it in combination. An automated audiometer with an ambient noise monitoring option and appropriate circumoral earphones permits what kind of testing outside of a sound booth? So think of the kind of testing we've been talking about, the kinds of procedures we've been talking about that are kind of the mainstay of audiological assessment.

All right, now let's talk a bit about monitoring ambient sound. There are ways of doing it. If you're in a setting that is not a sound booth, immediately you have to have some way of documenting the sound, ambient sound levels in that environment and you, not only for your own purposes and to make sure that it's quiet, but you really have to document it for medical legal reasons and to assure everybody, not just you, that you are able to get valid results in that environment. Well, one option is to purchase an inexpensive sound level meter. The one on the left is one I have right in my desk drawer here.

It's from Radio Shack, I think it was $35. But of course it gives you a single number and it's not frequency specific and it's. And it's. You don't really know where the sound is in the spectrum, but it is a decibel level which could be mentioned. So 49dB, you'd say.

Well, that that may or may not be maximum, within maximum permissible noise levels, but we don't know what frequencies that 49 decibels represents. So it's rather meaningless. Then next to that we have a, an app. Many of us have smartphones with apps. I'm very often I'll pull it out if there's noise level.

Just I'm curious to know how, how much sound there is. But it has the same limitations. Now there are most apps do provide you with some frequency information. As you can see with this one, it provides a spectrum, but you really have no way of documenting that those levels during an actual hearing assessment. So what we really need is an ambient noise monitoring approach where we know what the sounds are.

The ambient noise levels are at different frequencies, frequencies that we're actually evaluating in a pure tone assessment, for example. And we need to have some way of documenting those levels for our records and to prove that the test environment that we were functioning in was adequately quiet.

Now, so I pretty much summarize some of this slide. We need frequency specific measurements of ambient noise levels. That's essential, not, not an overall DBA level. And that's all that's really been appropriate or available for many, many years. And then we also need to make sure we're using transducers, earphones that attenuate ambient noise as much as possible and where that amount of intense attenuation is documented.

So those are, those are two things that are really essential when you're talking about measuring hearing, assessing hearing outside of a sound booth. Now, there is a third component that's optional but really quite valuable, and that is in addition to being able to monitor ambient noise frequency by frequency and to know that the transducers that you're using to test hearing are attenuating ambient noise in the environment, ideally you would want to have an automated device so you as an audiologist don't even have to be present to do the testing. I mean, that really opens up the possibility to perform assessments in multiple different settings and physical locations, geographical locations rather than where you are all the time in the traditional clinic. Now, as I mentioned at the outset, I'll be talking about one device, but there are numerous devices and I won't say numerous multiple devices on the market. One is a Shoebox audiometer.

I believe it's a Canadian company which also includes a noise monitoring feature. I've not used it myself, but it's been available for a number of years now. When I performed a literature search, I was able to find three peer reviewed publications describing the Shoebox audiometer using noise monitoring. So there's a little evidence out there in support of it. Then there's the South African system, the one developed by a physician in South Africa, the Kudu Wave Pro audiometer.

It's been out for quite a few years and it also has noise monitoring option. It's a standard feature of that equipment. And when I did my literature search, I found nine peer reviewed journal articles describing the Kudu wave and documenting Its, its effectiveness. And then the one I'll be talking about, the

automated audiometer, is the GSI Audio Star Pro with the AMTAS option. The AMTAS software permits automated assessment, which I'll talk about more in a minute.

And when I performed my literature search for the, for the AMTAS software and noise monitoring, There were over 10 peer reviewed articles. All right, here's the next question and this will kind of get you focused on what I'm about to talk about. Which US Standard defines the requirements for an adequately quiet hearing test environment? So think about, first of all, think about the, the standards organization in the US with what it, you know, what name of it or the abbreviation and then what standard.

Now I mentioned a CUDU wave. Let me just go into that a little more detail just to show you how automated hearing assessment can work and where it can be done and this importance of documenting ambient noise. What you see here is a photograph that I took in a small village in South Africa outside of Pretoria and Johannesburg. And it shows the facilitator, a tester over on the right, the woman on the right, and then it shows the patient on the left. And the facilitator is not an audiologist.

She is actually a former patient in this clinic who's been taught how to perform relatively straightforward tasks. For example, placing an otoscope into the ear and taking a video otoscopic image, or placing the bone vibrator on a patient's forehead. As you see here, there's a bone vibrator on the forehead and cup type earphones over the ears. After insert earphones are inserted in the ears and then either she can instruct or the facilitator can instruct the patient. Or very often with an automated device, the instructions can appear on the screen, the instructions for say pure tone audiometry in any language that you wish.

And so all, all the facilitator or whoever's helping with this testing, again not an audiologist, all they need to do is turn on the equipment, put the earphones on the bone vibrator, give the patient a response button or tell them how to respond. And the rest is automated. So this is well researched both with the

KUDU wave as well as the GSI Tempstar Pro. And here's an article that I was part of describing how pure tone audiometry can be conducted outside of a sound booth and how ambient noise can be monitored throughout the assessment. Well, now we're going to focus on the system that was used in the study that I'm about to describe.

I think Most of you are familiar with the GSI audiostar Pro audiometer. It's the latest generation of GSI audiometers and it's digital rather than the old style. And it also allows you to use software which has been developed by Dr. Robert Margolis for automated assessment. Now, the AMTAS, abbreviation or acronym refers to automated method for testing auditory sensitivity. So it's software that basically replaces the brain of an audiologist.

And when Dr. Margolis first described this, I remember being at a state meeting. It was, I think it may have been the very first time he described this new software. And I was sitting in the back, I wasn't speaking yet. I was going to be giving a lecture later on hyperacusis. So I thought, well, I'll listen to Bob Margolis give his presentation.

And I, I was glad it wasn't me giving the presentation because he was almost attacked, not physically, but certainly verbally. I mean, people were so threatened by this concept of an automated system that could actually perform a hearing assessment, pure tone audiometry, with as much validity as an audiologist, a skilled audiologist, in fact, sometimes. Some of these early papers on the AMTASP showed that automated audiometry was sometimes more accurate than audiometry conducted by an experienced audiologist. So this system is very, very well researched and there's a lot of evidence and supported. So that's one component of the equipment that, that was used in the, in the study that I'm about to describe.

The second very important piece of equipment is an earphone or a transducer, I should say, that provides a high level of attenuation so that if you're in a noisy environment with this earphone over the

ears, much of that noise is not reaching the ear itself. Now, these are radio ear earphones. They're relatively recent. They kind of replaced the, what was the generation before these was actually Sennheiser earphones some of you are familiar with. And these are circumoral.

Circumoral means that they're all. They're not pressing on the ear. They're. They're pressing on the skull, are all around the ear, but not on the ear itself. And if you ever put these earphones on there, they reminded me of the old audiophone.

So we used to use for ABR back In the late 70s and throughout the 80s, the red and the blue ones, and they're very tight. I mean, as soon as you put these on, you realize there's not much sound underneath these earphones. Most of the ambient sound is being attenuated. And we're going to I'll show you exactly how much attenuation you can achieve with these earphones in just a moment. And then the third most important component is a microphone, a very good microphone that is placed right where the patient is or the participant.

If it's a study picking up any ambient noise right where the person is trying to respond to the pure tones of the speech, whatever stimuli are being used. And this microphone is connected with a cable to the audiometer where and allows you to monitor ambient sound at different frequencies and document that both ongoing as you are testing and then later for your records.

Now I've mentioned this term maximum permissible ambient noise level several times, the abbreviations mpanl. So let me just refresh your memory on exactly what that is. These are ANSI standards, American National Standards Institute standards for the maximum noise levels that are permitted, that are allowable and to still obtain valid pure tone threshold results in a normal hear. So this is a definition from an article by Bob Margolis and and colleagues in 2021. The MPANL is the minimum ambient noise level that masks a pure tone threshold.

A pure tone presented at 0dB HL. So imagine that you're trying to record 0dB thresholds, normal thresholds, how much ambient noise can be present for you still to be able to do that for a normal hearing, perfectly normal hearing person to hear that faint, faint tone and record a zero db threshold. Now obviously that's going to vary depending on how much noise is in the environment to start with. It's also going to depend on how you're presenting the tones. So if you're presenting the tones in the sound field, so the ears are uncovered, so to speak, there's no earphone on them, then it's not going to take much noise for the person to mask out their ability to hear that tone.

Whereas if you have a transducer that presents a high level of attenuation, then of course the ambient noise that's permissible could be much higher. So it is an ANSI standard in the United States and there are international versions of that standard in other countries.

Next question. Question 4. Which type of this is, I hate to say, no brainer, but this is not going to be very challenging for you. Which type of circumoral earphone provides substantial attenuation of ambient noise for hearing testing? Now, if this were a quiz, a real quiz question, you'd have to be a little careful in reading it because I am referring to what type of CIRCUM oral earphones.

There are other types of transducers that provide substantial attenuation in addition to the ones I've just described. And of course you're all probably thinking, what about insert earphones? And it's very true that insert earphones provide a very high level of ambient noise attenuation. So the circum ear oral earphones, not the only option, of course. Course.

Move on to the next slide here. All right, so I'm leading up to the study that I was part of and I'll tell you how I got involved in it in a moment. And the equipment that was used. And of course all of this instrumentation is available to anybody to use. You know, these are all FDA approved in the United States devices for hearing assessment.

The you have the GSI Audio Star Pro audiometer, which you see on the far right, the picture on the right and the far right part of that picture you have the TDH, I mean not the TDH, the DD450 earphones, which you see in two of the figures, the arrows pointing to it and the figure to the right. And of course you can see them clearly on the person in the figure to the left. You have a microphone somewhere right in front of the person whose hearing is being tested. And then with the gsi, with AMTAS system, on the GSI Pro, you have a screen and a patient is given a prompt. So say you could be hearing a stimulus at this time.

Are you hearing it or are you not hearing it? They press yes or no. So all of the responses of the patient are automatically calculated. I've used this device, actually tested my own hearing with it as I was getting ready to be a consultant on this study that I'm about to tell you about. And it's very easy, easy.

Once you get the earphones on, the bone vibrator on, if you're the audiologist or you're the facilitator, you can basically just relax for a while. You can check your emails or Facebook because the patient's going to be tied up for another five or 10 minutes and you don't have to do a thing. And so it's a very, very easy procedure to administer once the patient's set up. And it does not require an audiologist, of course.

Now let's just talk for a moment about these earphones again, because they are a critical component, the DD450 earphones. And this is a study, another study by Dr. Margolis where they very systematically calculated exactly how much attenuation these earphones are providing that is how much of attenuation of ambient noise at different frequencies. And then they compared that to the ANSI standards for maximum permissible ambient noise levels and other earphones. So this is an article that you could easily find if you wanted to read all the details. Here we are, we've got another question.

Question 5. Which feature of ambient noise monitoring is essential in pure tone audiometry? So think back a few slides. What did I mention about a feature that's very very important during pure tone

audiometry?

While you're thinking about that, I'll move on. Okay, so this is a table from the article by Dr. Margolis and colleagues. Interestingly, unfortunately, the two co authors, Dr. Salley and Dr. Wilson, Richard Wilson are both recently deceased. So they were a part of this study and many many others. But unfortunately they're no longer with us.

I guess you could say they're in that great big sound booth in the sky. Well, here we have a table showing, let me get you oriented. On the left hand side are the frequencies. Now we don't usually use a stimulus of 125Hz, but it's there all the way up to 12,000Hz. That's the highest frequency there.

And then we have different amounts of attenuation for, or the minimum permissible noise level, I should say for different earphones or no earphones at all. So if you look at the earphone uncovered, which is the second column over, not counting the frequencies, that would be if you're trying to perform pure tone audiometry but you're in an environment which is not a sound booth and you're not using any earphone at all, you're just putting the sounds through a loudspeaker. For example, you see that you really can't have much noise level at all. You can only have noise levels of 12 to 13 or even 11dB for some of the high frequencies. So it'd be very very difficult, almost impossible to find a, a just a non sound treated environment that's that quiet.

Now if you're using the old type of old fashioned, I was going to say type of earphone, the DD TDH 50 there are other types, TDH 40s, etc. The supra oral sitting over the ears, you have a little more leeway. But still the noise levels when they get above 20dB are going to be too loud. The ambient noise levels for, for pure tone audiometry in that environment. But now let's look over to where the arrow is the column that it says DD450.

That's a circumoral earphone. We're only going to talk about that one in this, this presentation. And now look at how high the noise levels are. That because the circumoral earphone is such a, it's like a miniature sound booth on each side, it's attenuating ambient noise quite effectively. And therefore there can be more ambient noise without you worrying about it interfering or masking the pure tone signals you're presenting, even if they're at very low levels of say 0 or 5 dB.

So again, I'll emphasize automated audiometry and ambient noise monitoring are very important for performing audiometry outside of sound booth. But these earphones that attenuate sounds at this level are also very, very important. Okay, so what do we need for the noise monitoring itself? Well, you need the microphone. I've already showed you a picture of that.

But here it is again, high quality microphone sitting on a little stand, which is right in front of the patient, right where the patient's sitting in the room. And then you will see a screen. If you're using this software that has these little bar graphs at different frequencies, and you notice that the frequencies are that most of the traditional audiometric frequencies, certainly the, the octave frequencies without 3,000, 6,000. Now, typically, noise levels are not going to be highly frequency specific. So not being able to monitor at a frequency, say between 500 and 1000 Hz is not a limitation.

There's not going to be. It would be very atypical to have noise that's a specific frequency. It's usually more broad range of frequencies. So we have the screen to monitor. As the testing's being done, we have the microphone picking up the sound.

And then as the monitoring goes on, during pure tone audiometry, we have what's called the ambient noise check. So now we see that the bars actually are filled and the, the dark portion of the bar is the noise level. And so as you're actually performing the assessment constantly, it's ongoing. As you're constantly performing or the automated device is performing pure tone audiometry, there's this ability to monitor noise level in real time. And it's all in octave band noise levels.

Of course, if you see noise there, you know the microphone's working. You can constantly be monitoring as to whether or not the test environment is appropriately quiet. Now, realistically, and I'll show you some data on this, there are going to be times where for the most part, the room's quiet. Certainly it was quiet before you started the procedure. The assessment.

But then something happens. Somebody doesn't realize you're testing. They open the door, or maybe somebody's doing construction next door or somebody's phone rings. It could be any number of sources of noise. And if you're monitoring and you see that the noise levels are exceeding the maximum permissible ambient noise levels, you just stop the testing temporarily.

It's kind of comparable to those of you who perform abrs. If the patient moves, or if you have a child that suddenly gets restless and kind of moves around a little bit, but then settles down, you stop the averaging. So you're not collecting a lot of noisy data. So that's a huge feature. We're not saying that you only can perform hearing assessment where there's never any noise that exceeds the minimum permissible ambient noise levels.

Now, the big benefit here is once you've gone through this process of monitoring ambient noise during the hearing assessment, then you have a documentation of it. It's there for the record, and you can go back and look at it. You can prove to everybody what the noise levels were. So I'm not going to get into the detail, but you get a printout like this, what you see here on the left showing the average noise levels throughout the assessment. And you can have, and you can describe them in different ways.

Usually the ANSI standards are the way you'd want to describe it. How many times was the maximum permissible ambient noise level exceeded during that and what percentage of the time? So you know that's going to tell you how overall, how quiet or how noisy the environment was, the quality of the test environment, then it always provides you with the maximum noise level. When I start showing you the

data, you'll see that although the average noise levels may be well within ANSI standards, there almost always are going to be certain times when there's very, very high levels of noise. And then there's also what they call a distraction alert when there's sound levels exceeding 72.5 dB SPL.

I mean, at that point it's going to probably be a real distraction for the person being tested. So it'll also tell you when that's happening.

All right, again, we're right. We're moving right along here. Now. I'm going to actually describe the. The data in support of all the statements I've been making up to this point.

Data showing you that in the real world, evaluating performing hearing assessments with real people outside of a sound booth by an assessments that are being performed not by audiologists but by non audiologists, it's possible to get valid pure tone audiometric data. Now let me tell you about this, this project and how I got involved.

This project is the name of it. It's a very awkward acronym. It wasn't developed by an audiologist, that's for sure. It's called Limbic sensing. That's how the acronyms described.

It's a very large multi site project that's funded by the military, the dod, Department of Defense and the va. Large amount of funding and it goes way beyond hearing. It looks at many, many different parameters and dimensions. Psychological, neurophysiological, vestibular tinnitus, hearing, but many, many others. PTSD for veterans and military personnel who have mild traumatic brain injury. So the limbic sensei.

I'm not going to read the full description, but there it is. So this project is a longitudinal study. It's been going on for I'm not sure how many years, maybe 10 years. I got involved in about 2021, 2022 when they, the big group and the, the principal investigator realized that they needed a audiology consultant

because much of the data that was being collected was being collected outside of a sound booth and they wanted to make sure that everything was being done properly and particularly since non audiologists were doing. And a colleague of mine was then the chair of the department at the University of Hawaii where I was teaching part time online, Henry Liu, Dr. Henry Liu, he contacted me, said would you be interested in serving as a consultant for this big project?

So I asked for more information, I talked to the people involved and I thought this would be a wonderful opportunity for me to help out with this project because it's very worthwhile and it's, and it, and the data has to be good, has to be valid. So the first thing I had to do was write what's called a standard operating procedures manual which ended up being over 100 pages. And that's when I became very familiar with the, the GSI Audio Star Pro with the AMTAS software, et cetera because I had to describe how to operate it and all the troubleshooting that the non audiologist would need to do. So anyway, that's, that's the background on it. And since the study, since I've been involved, I've been monitoring and auditing all the auditory data collected.

Well now the study, the data collection stopped in this big, big project and we're now starting to analyze the data. So the auditory data were collected from more than 3,000 participants total. I'm only going to report data for a sub sample of 401 of those. And the data were collected in a quiet environment. The photograph I showed you earlier of the woman sitting in a room, that was one of the rooms, just a typical clinic type room, but these were not audiology clinics.

Now, in addition to pure tone audiometry with air conduction and bone conduction, the automated pure tone audiometry, this study also involves 2, 3 of the scan subtests, scan 3 subtests, the gap Detection test, Auditory Figure Ground test, and Competing Words, but I'm not going to talk about that. We will be analyzing all of that data, of course, and reporting it. So coming back to this photograph, this was a typical room. This was a room at one of the 10 sites around the country. Most of them were VA

campuses.

So there'd be a VA hospital, sometimes other buildings, but there were at least two military installations where the data were collected. So that was the setup. And off to the side somewhere would be the test. The person doing the testing, usually they were a research assistant working on the project. And the data would all be automatically collected.

And then the pure tone data would be printed out in a form such as the one you see on the right, traditional audiogram form, but with a few extra features. So my goal as a consultant would be to review the data and make sure that everything looked good, that looked valid and accurate, and there were no problems. Now, I'm going to just, I'm not going to go through all the details, but I'll just say that this software, there are some really neat features. One is that in addition to collecting the data and plotting the threshold, there's what in the upper right hand corner, what's called quality indicator data qualind. And that data basically includes reliability.

Was the patient responding in a reliable fashion? In this case, it was good. How long it took them to press the button every time they heard the data, you know, whether the results were consistent or perhaps suggesting some kind of false hearing loss. And then in lower portions of this graph, this is all this is printed out. As soon as the AMTAS pure tone audiometry is completed, there's a pure tone average that's automatically calculated, the description of the type of hearing loss.

Because air and bone is done whenever thresholds are worse than 10 dB. And then there's one of the neatest features of this is automatically, Dr. Margolis developed an algorithm for calculating asymmetry. So if there's significant asymmetry, it'll tell you. So any audiologist looking at this might say, wait a minute, I'm a little concerned about those high frequency thresholds in the left ear, there's that that might meet criteria for asymmetry. Well, if you look at the lower right hand corner, not all the way down, but toward the bottom on the right, you'll see bilateral symmetry.

And this is truly asymmetric. So this is kind of the printout that we gather, used as I reviewed the data to verify that everything was going as it should. Now, of course, we're going to talk about ambient noise levels, but we also have pure tone data. And you can see here that for the most part, these are the average thresholds for the right and left ear. This group of 401 participants.

And many of them are quite young, many of them are veterans for very recent conflicts. And you can see there, for the most part, they have pretty good hearing sense thresholds. A little bit of a high frequency loss on average. But if you look at the range, the right ear range and left ear, it goes up to 85dB to 100dB in high frequency. So there were some subjects with severe loss.

And by the way, ambient noise level monitoring is less important when you have somebody with a hearing loss because they're not going to be tested at 0dB or 5dB. But in any event, most of the subjects had just a mild high frequency, on average sensory loss. Okay, now we're going to get into the actual data very, very quickly. So we've got our audiometer, we've got our automated software for doing automated audiometry, we've got the microphone. We're collecting data for each and every subject for ambient noise levels as well as the audiometric data, all of that information, that data is going into a database to be analyzed.

Now, again, I'm going to remind you that the seric armoral earphones are a key component of all of this. And I just want to emphasize that by showing you this graph, if you look on the right, you see different types of earphones. The TDH50 earphones are the graphs that provide very little ambient noise attenuation. Almost none in the low frequencies and really not that much in high frequencies, 20 to 25 dB. And then you can see the DD450 earphones, which were used for this study and are used with the AMTAs.

And you can see the huge amount of attenuation even in the low frequencies. You're getting more than 20dB attenuation, for example, at 250, I mean, at 500Hz. And then of course, even higher levels for the high frequencies. So that's a very, very important Element of success in performing automated audiometry outside of a sound booth. Okay, I know this is a lot of information here, but I'm going to quickly summarize it for you and then we'll have time for some questions we have.

If you look down below in the lower part of the graph, I have two measures of MPANL. One is for octave bands, one's for 1/3 octave. They're not that different and you could use either one. But you see that the maximum noise levels permissible in a sound environment to perform pure tone audiometry. Let's just look at the 1/3 octave would be 32dB at 250.

So anytime the noise levels are greater than 32dB, even with the earphones, we wouldn't be able to perform valid pure tone audiometry. And then you can see the noise levels are actually higher, the maximum permissible for the higher frequencies. Now look at what I've highlighted. The top, top line of data. The ambient noise mean.

These are the ambient noise levels for this group of 401 subjects being evaluated with automated audiometry using the DD450 earphones. And you can see that the noise levels on average are always less, always well within the maximum permissible auditory noise level. So there's the data. You need to be confident that if you're evaluating a patient anywhere outside of a sound booth, it's possible to do so collect a valid audiogram without any interference on average from noise. You may need to stop the testing from time to time until things quiet down.

You might even need to make some adjustments. One way to use this kind of data is to, is to assess the same person, maybe a colleague, in different parts of a room, different locations, until you find the quietest place consistently and then perform the rest of your assessments there. Okay, well, that's my story and my explanation, my rationale and my evidence for why it is now possible or how it's now

possible to conduct audiology anywhere you want and not be constrained to a traditional audiology clinic and to a very expensive, immovable, sound treated booth. So with that, I'm going to take questions and we have a moderator who's been collecting them. I know that.

Thank you, Dr. Hall. That was a wonderful presentation. While people are entering their questions and I'm going to direct everyone to the Q and A as well to ask their questions. I did want to go back and ask you a question.

The booth has always just been a gold standard. Do you think that that will change with a lot of this information coming out? And as Technology continues to improve. Do you think you'll start to see changes in how people are going to be testing even, you know, in clinics all over the place? Well, let me answer that with two parts.

Number one. Well, those clinics, and this is most of them who have a sound booth, that have a sound booth. You know, if you have a sound booth, use it. There's no reason not to. And, and it would be very foolish to dismantle a sound booth and move it out if you already have one.

But certainly if, if you're a just getting started in the clinic or you're expanding your clinic and you want to have satellite clinics, and then there would be no this. I think these findings provide you with enough evidence to say to whomever is asking, we don't need, don't have to have a sound booth. Now, there are, there is at least one or two instances where I would recommend always performing pure tone audiometry in a sound booth. So if you had a busy clinic, you'd still want to use the sound booth, certainly for these patients. One is what I call forensic audiology assessments.

So it's a medical legal assessment. And I'm also a consultant for many, many forensic audiology cases where I review data. Sometimes I testify as a, as an expert witness. And one of the first things that the attorneys will do is they will focus right in on your calibration records and whether or not the sound

booth was adequately quiet. So even a single wall sound booth, without using just say the TDH earphones, the ones the supra oral wouldn't be adequate, you'd need to have more attenuation than that.

So that's one instance the forensic. The other is OSHA requirements. OSHA hearing tests require a sound booth. And you know, changing OSHA requirements or changing the way attorneys in the law view the sound booth, that's never going to happen probably. So there are times where a sound booth is essential mainly to prove to everybody.

As you said, gold standard was, was met. But other than that, in terms of billing for your services, in terms of the reputation of your clinic, there's plenty of evidence and it's being used. This is being done around the world where you can actually get all the results you need and high quality results outside of a traditional sound booth, certainly. And I might add, just one, one last thing I'm sorry for. Remember, the time you really need a sound booth is for thr assessment.

So in my clinics, when I'm performing an APD assessment, for example, or doing a tinnitus assessment, the Only time I'd ever use this need to use a sound booth is finding threshold for a person one. Of course, you don't need it for admittance measurements, tympanometry and reflexes. You don't need it for even OAEs, and you don't even need it for speech audiometry, which you're performing at a super threshold level. And certainly it would seem to be a much more effective way of expanding your clinic if you have it an audiometer. But you want to be able to see more patients, you could expand without having to, as you said, bring in that very large equipment.

And I hate to say this, but you could expand your clinic without hiring too many other audiologists either. And so, yeah, if I, as an audiologist, if I can see 100 patients a week instead of seeing 20 patients a week and get the same quality results, I'm, you know, that's what I want. Not so much from the revenue point of view, although that's not going to be bad. That's a good fringe benefit. But mainly

because you're helping more people.

There's so many people that need. Need the services. Exactly. One more question that I had for you about the study that you were involved in with all of the veterans. Were there any findings that you were surprised about or that you thought that it would go one way and it went a different way?

We haven't analyzed all the data. I, I was in my experience as an audiologist and of course all of us just about trained at some point when we're starting out in a VA setting. I was fully expecting more of the participants to have serious hearing loss. But of course, these, this is kind of a random group. It's not people coming into an audiology clinic.

So that was surprising. But if I known more about the population, probably I shouldn't have been surprised. I'll tell you one thing I was surprised about. As I was auditing charts, I would, for each of the sites or 10 sites, they might, they might see 15 or 20 participants in a month, sometimes more. And I would just look at a couple of audiometric data sets, maybe for two people out of that group.

And I started seeing asymmetries that really concerned me. So I developed an asymmetry called, I called it an asymmetry protocol, where I would then say, if you have a difference between ears that meets these criteria, and I started using the asymmetry warning on the audiogram for the AM test, then send this person to an audiologist or nolongaryngologist and they need to be worked up. So that was probably the biggest unexpected finding that in a kind of a typical group, for many of these people it was maybe a blast injury that damaged one side more than the other. But I think that the message to anyone using this technique and having non audiologists do it, monitor the data as the audiologist, don't just assume it's all accurate and definitely focus in on the same things we worry about in a clinic when we have a patient and one of them is an asymmetry and making proper medical referrals when there is an asymmetry. Oh, that's a great point.

One other area, ambient noise testing, seems to be really central to this whole idea. What are some of the common mistakes that clinicians make when they start using it? Well, that's a good point. First of all, you need to get the software loaded up onto the computer. And so there's technical, I know at GSI there's technical support and I'm sure there is for kudu wave and shoebox.

So if you have some trouble, somebody can walk you through it. And it's not like anything else. You're not going to get a valid threshold in a sound booth if you don't plug the earphones in or if somebody wild kid was there before and pulled him part way out. So, so just the normal tactical troubleshooting. And that's why I mentioned in one slide that if you see the, the bars on the noise bar starting to pop up, then you know the microphone's working.

But right at the outset you'd say, well, wait a minute, maybe, maybe I forgot to put the microphone right in front of the. You're not going to use it on every person perhaps. So maybe you're moving it from a drawer or shelf to the site. So just the normal troubleshooting. And anytime things don't quite fit or aren't right, using the crosscheck principle, say maybe you've done OAEs, now you're starting to use automated audiometry and noise and now you're getting hearing loss.

You, you'd want to say, well, this doesn't make sense. I need to find out what, what the explanation is. But otherwise it's pretty straightforward, easy to use. Once the microphone's in place and the software is loaded up, you're going to start getting these. Then it is up to you to be monitoring the watching the noise, monitoring as it's being done and to temporarily discontinue or pause the testing until the data collection, until things quiet down or take steps to quiet them down.

Thank you so much for coming today and talking about this. It was fascinating information that you shared with us. I do want to point out to the audience we are at the top of the hour, so I'm going to go ahead and just remind everybody that once this session ends, you can go back to Audiology Online to find and pass your exam. That is going to be located in your pending courses. And again, we want to

thank Dr. Hall for coming.

And we are so happy to have you here on Audiology Online. And I hope to see you again in the future. I hope to be back again in the future. Thank you, everyone, for attending.