The ABC's of Wireless Connectivity to Hearing Aids, presented in partnership with Seminars in Hearing

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- [Christy] It is my pleasure to welcome back Dr. Linda Thibodeau, who is a professor at the University of Texas at Dallas in the audiology doctoral program. She teaches courses in pediatric oral rehab, as well as conducting research with wireless-assisted technology, which she'll share with us today. Thank you, Dr. Thibodeau, and at this time I'll hand the mic over to you.

- All right. Thank you so much. I really appreciate the opportunity to share the issue that we produced on connectivity with AudiologyOnline subscribers, because this is a topic near and dear to my heart. And honestly, it's very hard to keep up with. Things are changing so quickly. So I will do my best to give you my understanding as it stands at the moment, and probably next week the presentation could change. So I really appreciate all the support that they give to put these presentations on. As she said, I teach at University of Texas at Dallas, and I wanted to direct you to our website, the Hearing Health Lab, and there is the URL, or you can just Google that if you don't want to copy that down at the moment. Hearing Health Lab has several of the posters and references that I'll be referring to as well as demos.

Also, I want to just take a minute before I start to extend my thoughts, prayers, concerns for those who've been affected personally by the pandemic that we are enduring and other weather-related challenges, the fires in Colorado. I just know there is so much that we are dealing with and really appreciate you taking time to be with me here today. Or if you're watching the presentation later, just know that I know it's a challenge for all of us at this time to navigate all of these things that are going on. And I really want you to know that I think about these challenges and how we're dealing and still focusing on our work to help those with hearing challenges.

These are my disclosures. As you can see there, there are various things I'm involved with. I also want to acknowledge my lab group at this photo taken very, fairly early into the pandemic when we first figured out our virtual meetings. That has been probably

one of the advantages of the pandemic is discovering more skills and benefits to meeting online. And I also want to gratefully acknowledge Phonak for providing remote microphone technology for the research and the training opportunities that they have afforded me. All right.

So today we're gonna do an overview of options for wireless connectivity to hearing aids. And then I try to break down the protocols into a basic structure that we can build on, and then how we can create a network of connections to meet communication demands for our participants, clients, users of the technology. So after presenting a rationale, we'll go through these protocols, and then I have a couple of examples of setting up networks. And as she said, I'll take questions throughout. I'll try to do my best to monitor that Q and A, because I really hate for people to go through struggling to follow something if I could answer a basic question as we go through. But hopefully we'll have time at the end as well. So those are your objectives that we will cover as well.

So as you know, whether you have hearing loss or not, much of our communication occurs in noisy environments. And even though people have sophisticated technology through hearing aids or cochlear implants, those are often not enough to achieve optimal communication. And many of our hearing aids and implants now have options for wireless connectivity beyond what we've had for many years, the telecoil, too devices that can facilitate hearing in noisy environment.

Now I'm grateful for, again, all of the persons attending, and I know there's gonna be a span of ages in the field, but those of you that are more on my end of the spectrum, you know that we've come from analog hearing aids to digital, and we thought all the great benefits that were gonna be for noise reduction, which there are, many benefits over analog hearing aids, but even then there are still some challenges. And long ago I committed myself to the idea that moving the microphone closer to the speaker was

going to be the best way that we could improve communication in noisy environments. So that's why much of my work has focused on the remote microphone technology.

So recently I've tried to think of ways that we can simplify this so that it becomes routine in your daily clinical practice. And so I love acronyms. So we came up with ABC of wireless connectivity and also use that for ABCs auditory rehabilitation, which actually I like to refer to as auditory revitalization. Excuse me. So you can make people feel more energetic after they've come to you to engage in your services through their auditory revitalization program.

But let's start with ABCs of wireless connectivity. I like this acronym because it implies that we're learning something basic because we all go back to kindergarten where you learned your ABCs, and that was basic. And that was the foundation upon which you could add more knowledge. And also, I think it implies a classification of terms and concepts into an organized system. So let's see if I can accomplish that today. So I took this notion of ABCs and put it into a pyramid, which I can call the Pyramid of Communication Success. And you'll see how then the ABCs of connectivity fit into that. So basically, if we think about the foundation and the basic part of every communication interaction, we would think about the A's, or the attending, advocate and arrange.

By attending, of course, we know we have to get the listener's attention before we're talking, or we have to advocate to our speaker to say, hey, I need you to face me, I need you to slow down, which I will try to do throughout the presentation. I need you to move with me to a quieter room, arrange the environment, turn down the noise. All of that is the foundation to improving communication. And if we can just remember when we're working with our subjects, our clients and patrons, that if we can just cover those A's, those three A's, then I think we will make potentially a significant impact for them in improving their communication. Then we can add onto that basics of technology.

And by that, I mean, just the basic hearing aid, ear level device, or cochlear implant, that's just going to allow them to receive the signal and then have it available for processing. Then on top of that, we can increase the benefits of the first two levels, the A and the B, by adding the connectivity. So I think of the lower level, advocate, attend, arrange, as the human factors. Those are things that we have to take care of. Then the second level, the basics, would be the non-human factors. And then the connectivity is to connect these human and non-human factors through the wireless technology, where we can exchange both connectivity to the personal device and then from the personal device to more sophisticated remote microphone technology.

So that's kind of how I'm building this as the ABCs, the basics from the foundation of what we can teach our clients to do as for their own benefit, without even any technology, then the basics of the technology. And today we'll focus on the connectivity. So when you think about connectivity, there's a lot of ways that we can connect, but I wanted to focus on connectivity for interpersonal communication today, rather than the large group audio systems that you might encounter if you go to the theater or to a large venue that has a loop or something like that, because those protocols typically don't have great portability such as infrared in a symphony hall or the induction loop systems.

But rather today to focus on improving that interpersonal communication. And to do that, I'm gonna cover these four protocols. So these connections and through these protocols would allow things to happen such as between connections, between ear level devices for binaural phone reception, or connection with remote microphones, to other assistive technology, or connections for binaural streaming of music. So those are just some examples of why these connections can be beneficial. And again, all of these can help us hear better in background noise. So we're gonna cover near-field

magnetic transduction, electromagnetic induction, frequency modulation, and then digital modulation. All right, so here we go. Near Field Magnetic Induction.

So we all know that connectivity options have increased drastically over the last 10 years. And one of the ways that that increase has occurred is through data exchange between two hearing aids in an individual wearer. And this happens through near-field magnetic induction. Now this protocol operates on a low frequency range, three to 15 megahertz. That allows the signal to travel easily through and around the head. So what that allows then is communication to happen between the two hearing aids or between the cochlear implants, or even the cochlear implant and a hearing aid. So that controls on one aid can synchronize, program, or volume changes. And also we could compare the signals arriving at each microphone to see which one is getting more noise, which one's getting more speech, and therefore adjust the settings to improve the signal-to-noise ratio to optimize that.

So near-field magnetic transduction is a wireless connection option that can improve hearing in background noise, but we'll focus now on the other protocols, because even this part alone isn't enough. Let's look at the other wireless options to enhance the signal-to-noise ratio. And there's just a little visual example of what we're trying to do here. We're trying to pay attention to a signal in the presence of background, and we want that signal to more or less pop out of the background noise. So in order to do that, let's talk about wireless protocols, the remaining wireless protocols, for connectivity between a listener and a talker.

So if we look at these, I categorize these into three main groups, electromagnetic induction, frequency modulation, and digital modulation. And we'll go through each of these in greater detail. The frequency modulation we could break it down into wide band and narrow band. And then the digital modulation, now this is important, I think for the structure not only of my talk, but also as you're talking to individuals about what

is contained in their hearing aid, the hearing aids are capable, and cochlear implants, of digital modulation, and that can be one of three basic types that I have categorized here as classic Bluetooth, Bluetooth Low Energy, and then proprietary digital modulation.

So again, we have three transmission protocols. Electromagnetic induction has been around for a long time. Frequency modulation came along several years ago and now has almost been replaced by digital modulation. And then there's further classifications within each of those. So what we do with these protocols is we can develop communication between a transmitter and then a receiver. Now the receiver can be, in a variety of ways, attached to personal technology, integrated, et cetera. We'll talk about that. But also we're looking at communication between that receiver back to that transmitter, for example, when you have a phone connected to a receiver that the hearing aid that user is wearing.

So let's start out with electromagnetic induction. I was surprised to find out that this was available back in 1938, a wearable hearing aid contained an induction receiver. And the way this works, as you know, a wire loop from a transmitter creates an electromagnetic field that mimics the original signal. So when a telecoil gets close to that loop, it's sensitive to the changes in the magnetic field and causes current to flow through the amplifier of the hearing aid to mimic that signal. This results in the signal from the transmitter to then be received at a greater intensity than what is arriving at the microphone of that hearing aid. Now here's a lovely body hearing aid that I found on the internet at that website showing the telecoil circled in red there.

So again, these were large units at the time, and we've had great advances to have not only miniaturization of the whole workings of a hearing aid, but also the t-coils in the hearing aids. Some advantages of electromagnetic induction and having t-coils in the hearing aids are that it's universal. So any hearing aid with a telecoil can go into a area

or communicate with a microphone that can transmit through the telecoil, in that you don't have to have a certain manufacturer, certain protocols, certain channel, or any of that. Switch your hearing aid to t-coil. Now there is quite a movement, alive and well, called Loop America. And I went to the website, which you can see there, and wanted to point out that there is a map on that website that shows you venues that provide loops and loop access to improve, again, audibility.

So many of these are the public large venue kind of places, but I just wanted to point out, I believe Michigan was where the Loop America movement started. And if you go to that entry, there's 656 entries of places in Michigan that provide loop access, compared to Texas which had 50 entries. So again, this is probably changing over time, but I just wanna point out that it's alive and well, that loops are still available. And it is my personal belief that every hearing aid should have an option, and cochlear implant, for a telecoil. And that way it's available. I also wanted to mention that I do consulting in several school districts here in North Texas, and when one of the systems goes down that we might be using, if the child has a t-coil in their hearing aid, I can easily get that child back up and running with a neck loop.

So it's an ideal system to have available. It's easy to use. There's no additional parts to add, unless, of course, we're adding a neck loop to access to that t-coil. There are some disadvantages. There is spillover with the electromagnetic signal from one room to another room if you have adjacent loops. You can also pick up stray electromagnetic energy from power lines or computer monitors. One of the ways we teach how to see if a hearing aid has a t-coil in it is to put it on a smartwatch, or even an old-fashioned watch that's ticking, even better, to listen and see if it's picking up that electromagnetic energy from the watch, or even some stray energy from light switches.

Or I had one participant I inadvertently left in t-coil in microphone mode when they walked out and hadn't given them the remote control yet to get out of that setting. And

every time they've pressed on the accelerator in the car, they heard unwanted noise. So we can pick up stray electromagnetic signals. It is also possible that there will be low frequency reduction energy because of the way the t-coil works. And that could be a disadvantage for people who need that low frequency energy. It's an advantage if you think about most of the background noise is low frequency. T-coils tend to be noisy. They can vary in signal intensity with head movements, we found in our research.

And manufacturers are not as often promoting telecoils now, but more likely the digital options through Bluetooth connectivity or their own proprietary system. So I ran across an article that actually pointed out, "What's going on? More loops and fewer Telecoils." So if you wanna explore that. We are seeing a reduction in the number of hearing aids that include t-coil. You can often call or find a model that will have the t-coil in it, but it's not as standard as it used to be, even though there's still quite a movement to have venues promoting loops. Let's move on to frequency modulation. So in frequency modulation, the transmitter modulates the signal from the microphone via a carrier frequency that then is demodulated by a receiver. And this operates on 72 to 76 megahertz, or now more likely 216 to 217 megahertz.

So some familiarity with FM, like when you get in your car, you go to your FM stations. That's the same idea. And typically they go up into the 100's or so. So now we're up at a higher frequency, 216 to 217, which has been designated for the hearing impaired. But systems can operate on either a wide band carrier frequency or narrow band carrier frequency, or a range of frequencies. The wide band frequencies are generally less expensive and have fewer channels. And the narrow band systems may have up to 40 channels, but there is some overlap. So in our conferences here that we have at UTD, we often had several individuals on FM systems in the same room. We could only do about six within a given classroom before we get some overlap. Now if you spread out, you can, of course, you get many more than that without overlap.

So the diagram on the right there simplifies the idea that there is a carrier frequency or that modulator. The signal from the microphone is then used to modulate the frequencies of the carrier wave, and you see that in the red there. And then that results, and the frequency modulation of the pink signal, or at least it's pink on my screen, where you see the correspondence of the energy in the modulator signal from the microphone changing the carrier frequency accordingly. And then that is demodulated by a receiver back into the original signal. So therefore it's important that we match our receiver to the carrier frequency that's carrying that signal from that transmitter microphone. So what are some advantages of FM? So now we have transmitter microphones that have sophisticated directionality.

So it's not only a benefit to move it closer, but also the orientation of the microphone can facilitate and improve the signal-to-noise ratio so that it may be reducing noise that's coming directly in front and be more sensitive to signals that are coming from above where the voice would be arriving and reaching that microphone. And that can result in significant benefits in speech recognition. We also have miniature FM receivers that can be attached to most behind-ear hearing aids via an audio shoe, which you see in the top picture there, or an integrated receiver in the turquoise aid below it, or two cochlear implants be an adapter. And also these receivers can easily be matched to the transmitter, just syncing with the button on the transmitter.

And they can be integrated actually into the case of a behind-the-ear aid or into a neck loop so that we can then receive the signal via FM to the neck loop and then induction to the t-coil of the hearing aid. And they can be integrated into ear-level technology for persons with normal hearing or mild hearing loss, and for individuals who have maybe auditory processing disorders or a unilateral hearing loss, or just a mild hearing loss, or maybe fluctuating. So it can totally be integrated into the case, but those are only for individuals with milder hearing loss. Some disadvantages. We have that limited number

of channels and we could get some overlap if we get too many active in the close range.

The receivers draw power from the battery of the hearing aid. And that we found in a study here that could reduce the battery life 50% if the aid was used 12 hours per day consistently. And the signal is not as clear as what we find with the next generation of the digital transmission. So let's move into the digital transmission. So this transmission operates on the 2.4 gigahertz frequency band, and it does so via frequency hopping rather than staying on a single carrier frequency. So if you think about maybe the carrier frequency with FM was 216.053 to 216.247, whatever little carrier band it was. This is now in digital modulation hopping around in that 2.4 gigahertz band.

So the likelihood of interfering with another system that's hopping randomly in that band is very limited. So we'll have limited interference with the system. This was first introduced in 2001 for use with hearing assistive devices. Now it's important to know that when we say DM, or digital modulation, that some devices that are capable of DM or receiving DM signals can operate on different protocols. So they're all in that 2.4 gigahertz frequency band, but the protocols can be standardized.

So a couple of standardized protocols are Bluetooth Classic and Bluetooth Low Energy. And then protocols can be proprietary. So Phonak has their own protocol, Phonak Roger systems, Oticon Streamers have their own protocol that communicate Oticon Streamer to Oticon hearing aid. Resound Multi-mic is a proprietary protocol that communicates with Resound hearing aids or cochlear and so forth. So proprietary means that it will only work within that manufacturer's line of products. So let's talk about each one of these. In the digital modulation realm, the Bluetooth Classic is something you might all be familiar with. We've had that around for awhile. It's available on smartphones, on computers.

And then initially intermediary devices such as the streamers would communicate Bluetooth Classic to a smartphone. So that was one of the first ways we connected to smartphones was through streamers around the neck that were proprietary then to send the signal to the manufacturer's hearing aid, but the connection to the phone was through Bluetooth Classic. And, of course, the device must be paired to communicate with each other. We had to pair that streamer to that phone. They did have high power consumption, but, as you know, the streamers all were rechargeable.

So we could plug those in and they likely weren't streaming 12 hours a day continuously. However, there was some temporal delay in transmission. Now that's not a problem when you're making a phone call because you don't hear the signal from the person you're talking to through the ambient pathway. They're in another location. So if there's a delay, that's not a problem. So it worked quite well, actually, for our initial connections to get binaural reception of phone calls into the hearing aids. So then came along Bluetooth Low Energy, and this was first available on iPhones.

So the manufacturers that made hearing aids compatible with iPhones, we're referring to those hearing aids as MFi or MFI, Made for iPhone, hearing aids. And then the cochlear implants manufactured by Cochlear also incorporated that technology. GN ReSound was the first to implement the Bluetooth LE protocol in hearing aids back in 2013. And again, devices must be paired with each other. So a hearing aid with Bluetooth Low Energy capability has to be paired with a phone, and the iPhone, with that capability. They had much lower power consumption. That's how we were able to then do this direct connection without draining our battery within a matter of few hours.

Some of you will remember the first connection we had, which was Bluetooth Classic, through the Starkey ELI, which doubled the length of the hearing aid and it lasted four to six hours. So it wasn't accepted at the time and went by the wayside. And then the

Bluetooth Low Energy came along and that solved that battery-drain issue, but then reduced range, and then we still had that delay in the transmission. Now let's look at the proprietary wireless protocols. Now we say these are available on hearing aids that we call MFA, or Made for All Phones. And to my knowledge, that would only be the Phonak line. It could be... But other proprietary wireless protocols can be available on specific aids and cochlear implants.

So, as we said before, an Oticon hearing aid can be compatible with an Oticon Streamer or an Oticon ConnectClip. That's all their proprietary wireless transmission, but it's digital modulation. So we can't take that Oticon ConnectClip and work with a Phonak hearing aid. And so the remote microphones then are the other use of the proprietary wireless protocols. And also as your streamers that connect to your TV and stream directly to the hearing aids, et cetera, that's again, proprietary wireless transmission. Again, the devices must be paired with each other to communicate. Sometimes that happens automatically. You don't have to actually go into software to do that. It does have low power consumption.

Again, the range is reduced and the delay now is minimal in transmission, so we can be talking to somebody, hand them a remote microphone, and not hear the delay that's happening through this proprietary wireless protocol. Also, an advantage is that we can use this protocol to transmit with more than one receiver. Now every wireless manufacturer protocol is different, but the Phonak Roger On, one of the newest microphones by Phonak, is capable, as their previous transmitters, of transmitting to multiple units. So it's a DM signal.

Again, it's proprietary to Phonak, and it can transmit to three individuals using say their Phonak Paradise hearing aids. So a little bit more about the Phonak digital modulation. They recognize the need for connectivity to Android phones. Data in 2018 already showed that Android accounted for 88% of the phones sold. So they developed a DM

protocol based on a proprietary chip that they developed, SWORD, that allowed pairing with Apple or Android phones. Now the SWORD acronym, which I was fascinated by, what does that stand for? Sonova Wireless One Radio Digital chip. That was referred to, as I said, as a made for all, or MFA hearing aid, because it could go iPhones as well as Android phones.

However, unlike the MFI or the MFi hearing aids that connected to both hearing aids, the MFA or the Phonak aids connected to a single hearing aid that you designate in the software. So a right-handed person may want the left hearing aid to connect to the phone so they have their right hand available for writing. But it's going to go to both hearing aids, it's just that if you forgot or needed to send your hearing aid off for repair, you could still connect if you designated the left hearing aid as the connection between the phone. If you had to send that hearing aid off for repair, then hopefully your audiologists would designate the single hearing aid that you had left as the connection to the phone. In 2018, they developed the bilateral phone connection to both iPhone and Android phones, and that was available in the Marvel product line and also now the Paradise.

So the connection between the two, which I think I should address right now, I think it comes up in a minute, happens through near-field magnetic induction. So the two problems that they had to address, battery consumption and binaural streaming, is accomplished in this chip called SWORD because it can utilize Bluetooth Classic and also supports Bluetooth LE. So they improve the radio sensitivity so it can handle the demands of the Bluetooth Classic while reducing the power consumption and maintaining that link stability. And in order to stream to both ears, I got ahead of myself, the Phonak developed a dedicated algorithm that extends the Bluetooth capabilities to allow that streaming to both ears. And how do they account for this reduced power consumption? I was fascinated by that. I was like, well, how does this work?

So again, this is a basic presentation, so we're not gonna go into a whole lot of detail, but this part made sense to me, that the chips, as you know, are getting smaller and smaller that are in these digital products. And with that, we can get increased processing speed and power consumption can be reduced because we have smaller transistors on the chip and they can be more tightly packed so the electron movement is more efficient and that can save time and energy. And with these smaller transistors, more can be added onto the chip, which can increase the sophisticated features without increasing the battery drain. So I found this comparison that I thought was interesting to compare the SWORD chip to other chips that are doing this wireless processing. As we said, the chip can process Bluetooth Classic, Bluetooth Low Energy, and also the Roger proprietary protocols.

And if you compare the current consumption, it's comparable to the MFi hearing aids, but far out performs the consumer wireless earbud. So if we look here, the SWORD chip on the left, and then the other 2.4 gigahertz MFi hearing aid chip, they're about the same size, 6.8 to 7.83, and similar power consumption. But compared to the consumer wireless earbuds, which, as you know, are rechargeable devices, so they do consume more power, and the chip is quite a bit larger. So what are advantages of the digital modulation? Limited interference. We don't have to worry about, again, these networks overlapping with each other, 'cause it's constantly changing through this frequency hopping.

So we can have unlimited networks. We get high signal quality through low noise and extended bandwidth. We don't have to search for available channels. We can just walk up and just create our network right then and there. And then some of the advantages that I mentioned for FM receivers also apply. These can be implemented in miniature receivers that attach to most behind-the-ear hearing aids via that audio shoe or that integrated system, or two cochlear implants via an adapter. They can easily be matched to the transmitter. They're integrated into the case as well or into the neck

loop, just like with the FM, and into ear level technology for persons with normal or mild hearing loss.

So all that was replicated with the DM system. Disadvantages. And again, it depends on how you want to look at these, but in some cases it might be considered a disadvantage because it is a proprietary network. So when you're using, let's say the proprietary network of the Resound Multi-mic to the Resound hearing aid, then should you update your resigned hearing aid to a different manufacturer, you've got the Multi-mic that was only compatible through the proprietary network with your older Resound hearing aid. So you have to be aware that when you go into these proprietary networks, that you're committing to that network and those accessories.

So the technology upgrades may then limit access depending on if you can upgrade everything at once, of course. Not all devices have adapters for DM receivers, and so that may be considered a disadvantage. And similar to the FM receivers, they do draw power from the battery of the hearing aid, but less than with the FM receivers. All right, so let's move into setting up networks. Again, I am committed to trying to help our profession understand that when we're working with individuals, we have to think about the ABCs. We have to tell them what they can do before they even get technology, what they can do in their environment. We have to fit them with the best personal technology. And we also have to think about what are their communication desires and challenges so that if we can set up a network of devices, we can really help them to do the best possible setup.

So whether it's a MFi or an MFA hearing aid or cochlear implant, let's think about the network options that we may consider for an individual. So number one, right there at the top in the middle, remote microphone. Again, moving that microphone closer to the source is gonna help us improve the signal-to-noise ratio, hands down. Then perhaps TV or some other Bluetooth-transmitting device is something we need to connect to, or

a smartphone with Bluetooth Low Energy capability, or smartphone with Bluetooth Classic capability. Community ALD, maybe at the theater, or it's part of their enjoyment and their entertainment, going to theater, or maybe to a church that has a certain type of system that they wanna connect to.

What about computers or tablets that have Bluetooth LE? Or maybe they have Bluetooth Classic. So what is it in their environment? And I probably couldn't give a presentation without mentioning the TELEGRAM, which is another pneumonic that can help you address all their communication hobbies, even can they hear their smoke alarm? It's a tool on my website that you can look at to see what areas they may be struggling in. That's not the focus of this presentation, so I didn't include it, but just wanted to mention it. Let's talk about some questions that we might wanna ask to determine the network options. Now I have to admit these are not incorporated into the TELEGRAM yet.

There may be a TELEGRAM supplement because in order to get to some more of these detailed arrangements, we need to ask some questions such as, what style of microphone do they prefer or need? Do they need something they can set it on a table and pick up sounds from all around in a group? Or do they just primarily want it for individual use or large group settings? So what would they prefer, or even yet, what would their communication partner style? What style would they accept and prefer to use? Do they have that communication partner that they frequently interact with, and what are their thoughts and would they be willing to wear the microphone? And could we get them excited about the potential of not having to repeat information? And we need to consider that.

We can't just be saying, oh, here's a remote microphone and this will help you a lot, and then not realize that the significant person that they communicate with is not willing to use that. So we need to incorporate that into our plan as well. And at the end,

price range can definitely be considered. Some of these have more features and bells and whistles, and some of them are basic. For me, the microwave with 30 seconds to a minute is fine. I can hit that minute button repeatedly and get the five minutes to melt the butter, or I can have all these options on my microwave, soften the butter, melt the butter, how many sticks of butter, et cetera. I can deal with the basic.

So we need to know what their thoughts are in terms of how sophisticated the technology is. And that kind of gets at a question that I didn't include in this list, and that is, how tech savvy are they? It should have been the first question on the list actually. So do they do online shopping? Do they connect their phone to other wireless technology? So how savvy are they and willing to learn the new techniques or troubleshoot when they need to? And that kind of gets into what smartphone do they use. So if they are interested in having that hands-free option to go into their hearing aids and have other streaming capabilities from podcasts or music, then, of course, knowing what phone they have is gonna be important.

So we can consider those options. Are there audio devices other than the smartphone to which they want to connect such as the TV or the tablet? And again, how many extra devices do they want to have? Maybe they just want to have one device and they want to set it next to the TV and not have a separate TV connector to work with. This is a big one for me. Are they okay with multiple chargers? Do they want to charge a separate streamer device that connects to a separate connect microphone, or do they want to keep it as simple as possible and just have the rechargeable hearing aids and maybe one other rechargeable microphone that's then gonna connect with multiple things?

And I added this one in here. Can they hear their smoke alarm without wearing their personal device, or do they need an alerting app? Maybe we need to connect their phone to an app that's going to detect alerting devices and either create a flashing light or a vibration source. And again, this may not connect directly to their personal device,

but it's still our responsibility to make sure that our patients can hear smoke alarms and even sirens while they're driving. And we have apps that are available now and encourage you to attend more of our Wednesday sessions in January, because we are gonna be talking about some of those apps. I think it's next week, actually, to help our patients connect with technology or with visual information on the phone where they don't even need any remote microphone.

Maybe they just need captioning. Okay, so let's take an example now, sample network number one. Fictitious case studies that are kind of a combination of many things that I have seen and worked with and experienced myself. So this first one, Nancy has a severe bilateral sensorineural hearing loss since birth, and she's re-entering the workforce after taking care of a medically fragile child who's now entering public school. So she's gonna be working in an advertising agency where she will give presentations to groups of individuals via ad campaigns, and her hobbies include attending the symphony and horseback riding. So she's ready for new technology to help her, take on the communication challenges she's gonna find in these environments.

So here's a network that might work for her. The Bilateral Paradise hearing aids with Roger receivers installed. So I mentioned that briefly, but let me point out again, that instead of attaching a Roger receiver to the hearing aid, like we might've done with an FM receiver, these receivers can be installed in the hearing aids that communicate then directly with the Roger technology, so there's nothing additional added on the exterior of the hearing aid. And that could connect to then the Galaxy phone that she has and stream the phone calls to both hearing aids through the one hearing aid designated as the connected hearing aid, and then through near-field magnetic induction streaming to the other hearing aid. Now there's also an app that will control the Roger ON microphone options, such that this Roger ON microphone can act as an omnidirectional microphone.

So if you lay it down on the table, it's gonna be sensitive to its orientation being horizontal and say, oh, we should go into omnidirectional mode to pick up from around the table, But it also has the capability to, like the previous microphone, Roger Select, to address a separate microphone and focus only maybe on picking up people on one side of the table. So with the Roger Select, and you would have to select that microphone by touching, but with the Roger ON, you can use an app on the phone that will then allow you to maybe more discreetly say, or attend, to people on one side of the table in a business meeting rather than...

So obviously pointing out that I'm just turning on the microphones for the people over here. So the husband thinks that this is a cool microphone, motivated to use it. She's actually going to lay that microphone closer to the TV because there's many TVs in the environment, several in her house, so she didn't want to have connectors when she's moving around. She's also gonna give this microphone to the riding instructor when she engages in her hobby of horseback riding so that she can hear as she increases the distance. And again, that may be limited depending upon the size of the arena, but it'll add some improvement. And then she may connect to assistive technology via the analog audio cable at the symphony.

Sorry that got overlapped there a little bit. But when she goes to the symphony, they are providing an FM receiver to connect it to headphones, but she doesn't want to take off her hearing aids or put the headphones over her hearing aids. So what she's gonna do is disconnect the headphones, which is an audio out jack on that receiver that the symphony is providing, and plug in her audio cable that will then plug into her Roger ON microphone and transmit the symphony then to both of her hearing aids.

So she can use this microphone then to connect when she goes into this public venue. Then she can use that Roger ON app to control that microphone settings and the

group arrangement. And she's also gonna use her Android smartphone with other apps so when she does get in difficult communication situations, or maybe her microphone ran out of charge, she can switch to an app we've been working with in our lab, Otter, that will then transmit, even in background noise, fairly well. We're actually using it kind of as a virtual patient in our research. So the keymar sets up with a hearing aid on, and then the output of that goes into this computer running Otter that will then tell us how clearly the signal came through this, whatever app that we're testing, or this whatever arrangement, microphone noise reduction that we're testing.

So the Otter app is working fairly well in background noise. And so she can use her phone for that and also for hearing signals in her environment and be alerted through an app called Sound Alert. So we're trying to take the whole communication challenge of this person, all the communication challenges she's experiencing, and put together a network, whether it's apps on the phone or the actual technology and the wireless connectivity that she needs. I do see a question up there. So let me see if I can address that. She can... So the question is, "Just to clarify, she can connect her Galaxy phone directly to the hearing aids for calls and audio. This Bluetooth connection does not require the Roger receiver." And that is correct.

So she could totally just buy the hearing aids, not by the Roger ON microphone, and connect those hearing aids to the Android phone. So the SWORD chip is what's allowing those hearing aids to connect to the Android phone, or she decides to get an iPhone. Maybe she's like me and the family has decided to switch to iPhones and develop photo streams and that's the only way she can see pictures of her grandchildren is to switch to iPhone. So with those same hearing aids, she could switch to iPhone and still get phones in both hearing aids. Hopefully that answered that question.

So let's move on to another example. And in this example, there we go, talking about Bill, he has an asymmetric hearing loss, and this time he is fit with a MED-EL Sonnet 2 Cochlear Implant on his right ear for two years, and now uses Oticon OPN 2 RIC on his left ear. So he needed more power for that right ear and got the cochlear implant, but still is using hearing aid on the left ear. Now he's a high school chemistry teacher and his main complaints are hearing the students during the small group lab sessions that he conducts in his classes. So I think they still teach this way where you have lab table, lab groups, and they might be assigned a project and you work on it as a group.

And so he has several of those tables in his classroom, and he needs to be able to hear questions, ask questions to those groups, and hear their responses. But he also has challenges, when he gets home after a long day, communicating with his wife when they're in the kitchen with all the reverberates surfaces and cooking dinner. So he'd like to be able to hear better in that situation. And fortunately, Bill is in a network of school district where they're willing to purchase anything because he's such an outstanding teacher, and they're very progressive in providing accommodations for their staff as well as for their students in this district. And they just said, tell us what you need. So for Bill, then I wanted to point out how you could start putting together a network perhaps by going to websites. This is the Roger Configurator, which will give you information about the DM options. There's also other websites that will give you information about the Oticon FM products and how they can connect.

But let me just point out, as you get to this website, you can put in the manufacturer, you can put in the model, and then you can choose a transmitter, receivers, et cetera, and it'll tell you what options are available for that. So remember we have the right ear with the MED-EL Sonnet 2 Cochlear Implant, the left ear with the Oticon OPN 2 RIC. So I would suggest in this case, and there could be other options, I'm just pointing out one scenario here, to get the Roger Select transmitter for use at home while cooking and watching TV. So this is the circle one that has the multiple microphone selections.

A Roger 21 will pick up the signal from this Roger Select transmitter on his cochlear implant so he can just put that on and leave it on and wear that all the time, and only use it when he's connected. I mean only use the DM part of it or the Roger connection when he's communicating with the Roger Select. But then to connect to that Oticon OPN 2 RIC, I would suggest the Oticon Edumic, which has proprietary streaming to the Oticon OPN 2, and it can work as a microphone too.

But it's only gonna transmit to that Oticon hearing aid. But if we add that Roger receiver, which I'm suggesting with that little green arrow, that you can plug in there to the euro connection, three pin euro connection, you add the Roger receiver to that. You can leave the Edumic sitting on the counter or close by or in his pocket, then it's gonna pick up from the Roger Select microphone and transmit to the Oticon OPN 2 hearing aid. So basically single microphone for his wife to wear or set on the table or near the TV to pick up and transmit directly through the Roger protocol to the Roger 21 on his implant and then through the Roger receiver connected to the Edumic that will then, through proprietary Oticon streaming, to the Oticon hearing aid, that he could pick that up.

Now the reason I went with the Select microphone is that rather than him using an app and trying to pick which table and which microphone to listen to, the school district could be asked to buy a Roger Select microphone for each lab table at school. And then his students are gonna need to be instructed, obviously, which would be good advocacy training, to know that all of those microphones in that classroom, the one on each table, has to be muted until the student wants to talk. And then they can select the microphone. Those microphones are gonna be set up in a network that are then all gonna transmit to the receiver on his Edumic and the Roger 21 on his cochlear implant.

So let's say Bill says, "Johnny, what's the value that you're reading on your test tube, or what are you seeing happening? What reaction are you seeing happening over there in your test tube?" And that student can then activate the microphone, unmute the microphone, activate the one that's gonna be directed towards his or her speech, and answer the question. And then the instructor would hear it. Now we could also throw in a sound field system if the school districts willing to buy everything, and then the whole classroom's gonna benefit from that connection. So that way Bill can hear each of the students directly, as long as all the microphones are muted except for the one that wants to talk. When they're unmuted, then they automatically go into lanyard mode.

So that's another example, and we have a couple of questions here, so let me see if I can answer those. So for Phonak, are the Roger mic and the PartnerMic the same product with the same purpose? So according to my understanding, they are different protocols. So when you use the PartnerMic, you don't need a Roger receiver to make that connection with that hearing device. So the PartnerMic will stream. It's like that proprietary streaming of the ConnectClip, Oticon ConnectClip, to the Oticon hearing aid. However, when you use the Roger mic, you do need the Roger receiver installed for that connection to be made. So I hope that answers that question, but as far as the purpose, yes, they are both designed to improve the signal-to-noise ratio by moving the microphone closer to the source.

Now as long as we're comparing, I must say that the PartnerMic's gonna be less expensive than the Roger mic, and the PartnerMic is going to have less sophisticated microphone options. There's gonna be some directionality to it, but not the same as a Roger microphone, either the Select or the ON, that's gonna let you pick or automatically select a conference mode or omnidirectional mode versus when you put in an upright direction, it's automatically gonna select a very focused lanyard mode pickup. So you're not gonna have that flexibility with that. Also PartnerMics can not be networked so that you would have one PartnerMic transmitting to multiple receivers

like a Roger mic could, or that you could have a PartnerMic on every table in this classroom, and then him pick up from multiple PartnerMics.

And then another question. "I have noticed students using the Edumic with Roger for one side and Phonak Roger directly to the other side. Notice a slight delay between the sides due to going through the Edumic. Have you found this? And if so, how have you resolved it?" I have not had that set up yet. So that could be applicable as you're mentioning in this situation. The ones that I have worked with... I'm trying to think if I have any. It's been elementary. My experience with this Edumic has been in elementary settings and I have not had that concern expressed in my experience, but I think it's definitely something that I could look into in the lab, and I appreciate your bringing that up.

I haven't asked Phonak that question either. So the Edumic with the Roger receiver on one side going to an Oticon hearing aid, versus the Roger directly on the other side. Now I do avoid a Roger on one side and FM technology on the other, just because I do know that there are some differences in the transmission protocols that could account for time delay. So I do try to avoid that. If I have to go to FM on one side because one's gotta be sent off for repair, then I would switch to FM on both sides until the repair came back. But I don't know that the delay was noticeable in the situation you described, but I certainly can look into that. Thank you for raising that question.

So let's move on. Let's see. I have to click here and then click here to summarize that there are significant speech recognition in noise challenges encountered technology. We know that for some individuals, this ear level arrangement is not enough. And we have a lot of research showing that remote microphone technology can significantly reduce these challenges. And as I pointed out, individuals are different, and every individual may have a need that is so great that they want to take on this extra technology, or they may simply be comfortable with what is provided with their ear

level technology. So we have to investigate that for each individual. The wireless connectivity has dramatically improved from that original electromagnetic induction to FM and now to digital modulation. So remember, I know a lot of people say, "Oh, can you get an FM system for this child? They just got Paradise hearing aids."

So I encourage you to try to be specific about the terminology that you're using now, so that what we're putting into the Marvel and the Paradise hearing aids is not an FM system, but DM system. And I also want to point this out to the school districts I work with because I want them to be able to be advocates to their parents of the children they serve that they're using this latest and greatest technology. That they're getting digital modulation receivers for their child. And also the correct, the technology that if a parent says, I just bought a Bluetooth hearing aid for my child so now he can connect directly to the teacher's microphone. Well, that depends on what microphone the student is using in the school district.

So I encourage you, if you're not involved directly with school district equipment and you're fitting a child, to be sure you can communicate with that child's educational audiologist about what system they may be trying to connect to in school, especially if we're talking about loops, because there's been confusion about whether it's a Phonak streamer and now they lost their Phonak hearing aids, and now they come back with Oticon hearing aids and find that the streamer doesn't work anymore.

So it's important that we recognize these proprietary connections and communicate with our school districts of childrens that we're serving. And finally, networks between remote microphones and hearing aids or cochlear implants can be provided to address a variety of communication challenges. Please think about more than just verbal communication and all the reasons that they may need to connect and how what they're wearing on their ears can improve their lifestyle and quality of life. I'm happy to take more questions.

I wanna thank you for your ABC attention. Kind of gotten into these acronyms at the end of my talks. So this one stands for Absolutely Brilliant Concentration. And I'm thankful again for you to take time out from your busy schedules during these pandemic times, and also have to just throw in a plug for the window face mask, the transparent face masks. There are some that are FDA approved. Look for that demo on my website, and you can actually see the benefit of then using this remote microphone technology with face masks, and encourage you to consider that as well because that's absolutely increased our communication challenges for the people that we serve when we have to listen without getting those visual cues. Thank you again for your attention. There's my website and my email address. I'm happy to take any more questions. Thank you so much.