Beyond the Ear: Effects of Adult-Onset Hearing Loss and Hearing Treatment on Neurocognitive Function & Well-Being

Presenter: Hannah Glick, AuD, PhD, CCC-A

- [Christie] It is my pleasure to welcome to Audiology Online, Dr. Hannah Glick. Dr. Glick, today, will be talking about effects of adult onset hearing loss and how it affects our neurocognitive function. Dr. Glick is an Assistant Professor at the University of Northern Colorado, and I'd like to hand the mic over to you, Dr. Glick.

- Thank you so much, Christie. Well, I am very excited to be here today and excited to get to talk about this topic. So a little bit about my background and training. I am an audiologist first, and I am also a cognitive neuroscientist. And today what I'll be sharing is some of my research looking at the impact of hearing loss and hearing treatment on the brain, on cognitive health, wellbeing, and how this information might inform our clinical practice. So just to reemphasize, please type your questions as they come up into the Q & A. We'll monitor those and I will try to answer questions as we go or may take some questions at the end, obviously as well.

So here are my disclosures and here are the learning outcomes for this webinar. But before we begin, I'd like to just start with a little bit of a reflection exercise. So I'd like you to take a minute and just reflect on the types of information that you use in your own clinical practice currently, to determine who is a good candidate for amplification and to assess treatment outcomes. So this is a two part question. First question asks you what kind of information do you currently use, to determine candidacy for amplification? And second question, what types of information do you currently use, to monitor outcomes following treatment with amplification? Just give everyone a minute to respond. All right, and I pulled up the responses that I got.

So it looks like almost everyone, not unsurprisingly, is using pure tone thresholds as a determination of who might be a candidate for amplification. And a good portion of you, are also using unaided speech and noise testing, about 66%, to figure out who

might be a good candidate for amplification. Much lower number for other health measures, for example, physical, mental, cognitive, social wellbeing, a much lower percentage there. And then in terms of outcomes that you're using to monitor treatment success, with an amplification. I love seeing these numbers. A lot of people are using probe microphone measures, real ear measures, 92%, to look at treatment success and outcomes. Smaller portion, about 35%, are using aided speech and noise testing. And then a smaller percentage, even smaller percentage, are using other health measures to monitor outcomes.

So listen, I think this is great. I love that so many of you, are using more than one piece of information, to determine who might be a good candidate for amplification, and to monitor treatment outcomes. At the same time, I hope by the end of this webinar, this will get you thinking beyond just auditory outcomes, hearing centric outcomes, more holistically, in terms of how you might determine candidacy or assess outcomes in your patients, using cognitive health measures or other measures of things like social wellbeing. So before we dive in, I want to share a little bit of a personal story. So the reason that I became an audiologist, the reason that I decided to pursue my PhD in neuroscience and cognitive science, is really because of my grandmother.

My grandmother started developing hearing loss in midlife, which was exacerbated by genetic kidney disease. And in the very beginning stages, my grandmother's hearing loss, it happened very gradually. It was really hardly noticeable to her or to the rest of our family. But slowly and over time, I witnessed the cognitive, the social, the mental and emotional impact that hearing loss had on my grandmother's life. And she, like so many other adult patients, that I've seen over the years as an audiologist that share a similar story, they're the reason that I became a clinician. They're the reason that I became a scientist, and really the motivation for this work and the research that I do. So let's start with a little bit of background.

Many of you probably are aware of these statistics, but I think it's important to start out and emphasize that most of the public, our patients that come into our doors, are not necessarily aware of these statistics. So the occurrence of hearing loss, is quite common in adults. By 2050, it is estimated by the World Health Organization, that one in four people will have a hearing loss. So thinking about my grandmother and her hearing loss that started in midlife, really she's not alone. And we know that as a person advances in age, the incidences in prevalence of hearing loss increases, it becomes more common. And unbeknownst to many, including the public, hearing loss is actually more common than diabetes and cancer.

It is actually the third leading chronic health condition after high blood pressure, hypertension and arthritis. Yet despite the high incidence and prevalence of adult onset hearing loss, particularly in adults, the situation looks different in children with hearing loss. But the unfortunate reality is that very few adults, who have hearing loss use hearing aids, less than 10%, in fact, over the age of 45 years. And in addition to the low percentage of uptake and use of hearing aids, there is also a long delay between initial onset of hearing loss and when an adult seeks treatment from an audiologist. The average adult waits about 10 years, a decade, before they come into our office looking for solutions. So I've heard this story from many adult patients before.

Some of them say, so I have a hearing loss, so what? Most of my friends do, it's a part of aging. I hear this often, but the reason that we care about hearing loss, is because hearing loss has an impact, beyond just hearing and communication. And there's a growing body of research evidence, showing that hearing loss is linked to many adverse health outcomes, cognitive function included. So according to several recent large scale meta-analyses, hearing loss is independently associated with about a two times higher risk of cognitive decline, including dementia. But why does this link between hearing loss and cognitive decline exist? What is this link between hearing loss and cognitive function? And second, what do we do about it?

Well, in terms of this link or underlying causal mechanism, linking adult onset hearing loss to cognitive decline, we really don't have all of the answers to this question yet. But there are a couple of hypotheses surrounding this link between hearing loss and dementia. So let's talk a little bit, about some of the current hypotheses. So one hypothesis is the Sensory Deprivation Hypothesis. So this is the idea that hearing loss, causes gradual changes, in both structure and function in the brain. And these changes in brain structure and function can in turn affect cognition. So the the idea with Sensory Deprivation Hypothesis, is that this link or association, between hearing loss and cognitive decline is due to deprivation to those neural pathways in the brain, which cause changes in brain structure and function, and then in turn affect cognitive function.

A second hypothesis, is what's called the Information Degradation Hypothesis. So this is the idea that hearing loss creates a distorted auditory signal. So by the time that auditory information reaches our cortex, where we ultimately perceive and make sense of sound, that the signal is degraded, and when the signal is degraded, that causes errors in our auditory perception, which in turn, can affect higher level processes like cognition. And then a third, third hypothesis is what's called the Common Cause Hypothesis. So this is the idea that hearing loss and cognitive decline are simply just two parallel processes, both of which kind of co-occur as we age. Now, as I mentioned, we don't yet fully understand why this association between adult onset hearing loss and cognitive decline exists.

And it could be a multitude of different reasons. The Common Cause Hypothesis has been really statistically ruled out, but the Sensory Deprivation Hypothesis, the Information Degradation Hypothesis, these are still on the table. And likely this relationship, between the association of adult onset hearing loss and cognitive decline, likely it's complex. And as we say, often in science, correlation does not mean

causation. And so more research is needed in this area, to really understand these potential causal mechanisms driving this association, if they exist. But recent meta-analyses do show that hearing loss is a risk factor for cognitive decline. And even more importantly, hearing loss, is one of the most potentially modifiable risk factors for cognitive decline. So this means that compared to changing other types of health related behaviors that might increase our risk for dementia.

So things like obesity, physical activity, diet, smoking, drinking, cognitive engagement, treatment of hearing loss with hearing aids, which is the most common, is a relatively benign intervention, compared to other modifiable risk factors, that require much more drastic modifications in terms of lifestyle. So this is really where my research comes in. I use a tool, a neuroimaging tool. It's a non-invasive tool called EEG to study brain changes before and after hearing treatment. So the research that I'm going to present today uses a form of EEG called High Density EEG, where we place a cap of 128 electrodes or sensors on an individual's head, and we record electrical activity, synchronous activity, neural activity from the brain, specifically the highest centers of the brain, the cortex, where perception ultimately happens in response to different types of sensory stimuli.

So in response to auditory stimuli, sound, visual stimuli, fibro-tactile stimuli, et cetera. So here on the screen, you can see an example, of the responses that we might record. And each of these waves that you see on the screen, is the averaged response, in response to lots of different sensory stimulus presentations at each electrode site or each sensor site. And in the center, you can see the cortical evoked potential or the average response across all of the different sensory stimulus presentations across all of the different electrodes on the scalp. And you can see some distinct peaks in this average response. Each of those peaks represent neural activity, coming from different locations within the cortex, within the brain.

So using High Density EEG and non-invasive neuroimaging, there are a couple of different things that we can study, in terms of the effects of hearing treatment on neuroplasticity in the brain. So one type of neuroplasticity that we can study is what we call cross-modal neuroplasticity. So I think of cross-modal neuroplasticity as kind of the use it or lose it mentality of our brain, where if one area of our brain is not being stimulated as it typically would, these brain areas may get recruited by other senses. So I like to put this in context with an example. So let's say that we have an individual that has hearing loss. Well, those auditory pathways in the brain are not being stimulated as they typically would because of the presence of a hearing loss.

So what may happen, and what cross-modal neuroplasticity is, is that those auditory or hearing centers of the brain, may actually get recruited or repurposed to process other kinds of sensory stimulation. For example, those auditory areas of the brain, might be repurposed to process visual stimuli or fibro-tactile stimuli. So that's one form of neuroplasticity, one type of brain change that we can study before and after treatment with amplification in adult onset hearing loss. Another type of neuroplasticity that we can study is what we call cortical resource allocation. So this is where our brain may recruit additional or alternative networks and brain resources for processing. So same example, we've got an individual that has hearing loss.

An example of neuroplasticity that we might see in untreated hearing loss, is where an an individual with hearing loss who's listening, may actually recruit additional or alternative brain networks. For example, networks of the brain, that are involved in attention and cognition during auditory processing tasks, kind of in an effort, to make sense of that degraded auditory signal. Now, in the very early days of this research, before my time, it was thought that these changes in neuroplasticity, cross-modal reorganization, changes in cortical resource allocation, it was thought that these changes were really restricted to severe and profound hearing loss. And there are many research studies documenting some of these changes in deafness, for example. But

what we are now learning, is that these brain changes, are not just restricted to severe and profound hearing loss, but they actually occur, even in the early stages of hearing loss.

So what I'd like to do next, is present some of the key findings from my research, in individuals with very mild and moderate hearing loss. So this would be hearing loss, that is mild or moderate in severity on conventional tests of hearing using pure tone audiometry. So first key theme or finding from my research, is that these brain changes are evident, even in hearing losses at very mild or early stages. So the images that you see here on this screen, are what are called cortical source activation patterns. Essentially, when we use High Density EEG, lots of electrodes, we can do some advanced modeling, to actually map where in the brain those auditory signals are coming from.

And we can map those source activation patterns, those brain activation patterns on a MRI image as shown here. So the images that you see here, are cortical source activation patterns, derived through High Density EEG experiments in a group of adults with normal hearing, that's over on the left, and a group of adults with early stage, mild to moderate sensory neural hearing loss. And in this case, these images are in response to an auditory stimulus. So we presented sound stimuli. It was a speech syllable that the individuals listened to over and over and over again, and we looked at activation patterns in their brain. So what do you notice? If we look at these images, you can see that in our normal hearing group, in response to auditory stimuli, our normal hearing group is showing expected activation, where you see those colors are, in areas of the brain responsible for processing auditory stimulation, areas of the temporal lobe, the auditory cortex.

But what about our hearing loss group? In the hearing loss group, the adults with mild to moderate sensory neural hearing loss, you can see reduced activation in those

auditory areas of the brain. This kind of makes sense, right? Hearing loss results in atypical stimulation of the auditory pathways. So by the time that information reaches our cortex, there's decreased neural activity in areas of the auditory cortex. But interestingly, if we look at brain activity, in other areas of the brain, in response to the same exact sound stimulus. What we see is that while the normal hearing group, shows activity restricted to areas of the temporal lobe, areas of the auditory cortex, typically associated with processing of auditory stimuli, the normal hearing group, is also showing activation of frontal and prefrontal cortex.

These are areas of the brain, that are involved in higher level skills, so higher level kind of processes, like attention, cognitive function, et cetera. So we're seeing this compensatory recruitment of frontal and prefrontal cortex when listening, in the hearing loss group. Additionally, when we present visual stimuli, so instead of sound stimuli, we present a visual stimulus to both groups. You know, in processing a visual stimulus, the typical activation happens in the back of the head, in the occipital lobe, areas of the visual cortex, involved in processing visually visual stimuli. And that's what we see in our normal hearing group. But take a look at the hearing loss group, in response to that visual stimulus. We're seeing activation not just in the back of the head, in areas of the occipital lobe, involved in visual processing, but also areas in the temporal lobe, in the auditory cortex.

So this is evidence, that even in the early mild stages of hearing loss, we see evidence of cross-modal reorganization and changes in cortical resource allocation. So that's key theme one. These brain changes are evidenced even in hearing loss's early mild stages. Key finding two, is that these brain changes, they happen really, really rapidly, within months of the onset of hearing loss. So we wanted to look at, how soon do these changes start to happen. And luckily enough, we were fortunate to have connection to an adult patient, who experienced a bilateral, sudden sensory neural hearing loss, likely due to a viral infection. So we had this individual come into our lab

and we presented visual stimuli, and we looked at these cortical activation patterns over the duration of this individual's hearing loss.

So the first time that we saw this individual, was pretty shortly after the onset of the hearing loss, the sudden hearing loss, within a week or so, of the onset of the hearing loss. And this is in response to a visual stimulus. So what did we see? So when we presented that visual stimulus, what we saw was most of the activation happening in the back of the head, in the occipital lobe, areas typically associated with visual processing. We had this individual come back longitudinally, at several points after the onset of the hearing loss. And here's what we saw at three months, and this is without the use of amplification or hearing aids, and you can see a big shift by three months, in response to that same visual stimulus.

Now, we don't see activation in the occipital lobe in the back of the head, in areas typically responsible for processing visual stimuli, but we actually see the activation happening in the auditory cortex, evidence of cross-modal reorganization, three months after the onset of hearing loss. And then if we look at one year after hearing loss onset, unfortunately this individual, even though they received different types of intervention, hearing never returned to normal. And we can see persistent cross-modal reorganization, even a year after the onset of the hearing loss. We'll talk about the implications of this in a little bit. So we know from this research, that these brain changes are evident, even in the mild stages of hearing loss, and that these brain changes happen very, very early on after the onset of hearing loss.

So the question becomes, what can we do about it? Can treatment of hearing loss, restore more typical brain function? The answer is yes. So in a recent study, what we did is we took another group of 21 adults with early stage normal sloping to mild to moderate sensory neural hearing loss, and we presented visual stimuli and recorded these cortical evoke potentials before hearing aid fitting, and then six months after

hearing aid fitting to look at brain changes over the course of treatment. So pre-treatment, at baseline, in response to that visual stimulus, our hearing loss group with mild hearing loss showed pretty widespread activation in response to that visual stimulus. So again, with a visual stimulus, we expect to see activation in the occipital lobe in the back of the head, we see a little bit of that.

But in the hearing loss group, we also see activation in areas of the auditory cortex involved in processing of auditory stimuli, as well as the recruitment of prefrontal and frontal cortex, those areas of the brain involved in attention and cognitive functions. So this is consistent with previous data that I shared, where we see evidence of cross-modal reorganization, changes in cortical resource allocation in untreated mild hearing loss. Now let's take a look at the patterns that we see in response to the same stimulus, after six months of hearing aid use. Look at that. So we see that cortical activity move back to the occipital cortex, so areas of the brain more typically associated with visual processing.

So we see a reversal in cross-modal reorganization, and we also see a reduction in the recruitment of frontal and prefrontal cortex, during this listening task. And so just a little bit of more information about the hearing loss group and the treatment. So all of these 21 adults, were fit with the same exact hearing aids. This was premium level hearing technology, and we performed real ear or probe microphone measurements to ensure adequate audibility. So all these participants were fit within 5 DB of prescriptive fitting targets, and they were also required to wear their hearing aids, for at least five hours per day on average, over the course of the six months. And we did periodic data logging to ensure that.

Isn't that amazing? So we were interested with this study to not just look at whether hearing treatments can change or drive changes in neuroplasticity, but also whether hearing treatment may modify cognitive function or cognitive health. So let's look first

at the impact of hearing treatment on global cognitive function. We measured global cognitive function using a very common cognitive screening tool called the Montreal Cognitive Assessment or MoCA, and we administered it at baseline and then at six months after treatment with hearing aids in these 21 adults. And just to kind of clarify, when we administered these cognitive tests at baseline, we administered the tests in an acutely aided condition. We wanted to make sure that audibility wouldn't be a factor that might influence performance on these cognitive tests.

So we wanted to compare apples to apples in the same exact test conditions at baseline to six months post-treatment. Was there an improvement in global cognitive function on the MoCA? And you can see that at baseline, the hearing loss group reformed pretty poorly on this global cognitive screener. You can see this line here on the graph is the cutoff score, and that cutoff score is 27 out of 30 points on the test. And that's really the cutoff score for risk, for putting the person at risk for cognitive decline. So if the person's score falls below that cutoff less than 27, they're considered at risk and are oftentimes referred for additional follow-up or referred back to their primary care provider.

So you can see on average in this hearing loss group, there was some variability in performance on the cognitive screening test, but on average, the hearing loss group, actually performed slightly below the cutoff. They were at about a 26 on average on the MoCA, so in that risk category for cognitive impairment. But look at post-treatment. So after six months of wearing hearing aids, at least five hours per day, well-fit hearing aids, you can see an improvement in global cognitive function, and this was statistically significant. We wanted to go beyond, just looking at global cognitive function, and we were also wanted to dig a bit deeper and look at the effects of hearing treatment, on specific aspects of cognitive function.

So we also administered other domain specific cognitive tests. We looked at executive function at baseline, compared to six months post-treatment. And executive function, is really this mental process of planning, decision making, monitoring, and executing tasks. So we measured executive function using a test called the Behavioral Disc Control Scale, at baseline and in six months post-treatment, we also wanted to look at processing speed, so the speed of mental processing during different tasks. So we used a task called the Symbol Digit Modalities Test or SDMT, at baseline and then six months post-treatment. And again, all the cognitive testing at baseline, was done in an acutely aided condition to negate possible effects of audibility on cognitive test performance.

And so again, on both of these specific measures of cognitive function, we observed measurable statistically significant improvements at six months post-treatment. So I see a question here. How did your rule out a simple repetition effect on pre-post global cognition results? Was there a control group? Yes, so I don't have those here in the slides, but we did compare changes to a control group. So we had our 21 subjects who had hearing loss. We also had a larger number of subjects, who served as our control group. And so at baseline, on all of these measures of cognitive function, the untreated hearing loss group performed more poorly, than the normal hearing group. Here on these slides, I'm just highlighting what we saw in terms of treatment effects, within the hearing loss group.

Great question. Another thing that we were interested in looking at, was the impact of hearing treatment on working memory. So working memory is a form of short-term memory, and we wanted to evaluate performance in working memory on two different types of working memory tasks, a visual working memory task, and an auditory working memory task. We were interested in seeing, whether these cognitive changes post-treatment were kind of domain specific. So if hearing loss is the issue or the problem, was only auditory working memory affected or visual working memory as

well, more domain general. So the visual working memory task that we used was called the Reading Span Test. And the auditory working memory test, was called the Word Auditory Recognition Recall Measure.

So in both tasks, they kind of work similarly, but one's a visual task, one's an auditory task. The participants were presented with a series of words or sentences in varying set sizes, and they had to hold some of this information and recall it after a short period. So for example, with the visual working memory task, the individual saw sentences on the screen, so they would see sets of 2, 3, 4, 5, 6 sentences at a time. And after they saw that set of sentences, they were asked to recall the first word of each sentence. So they had to hold some of that information in their memory for a short period of time and recall it later. And so what did we see here?

Well, post-treatment what we observed, was a significant improvement in visual working memory, but we didn't see a significant improvement in auditory working memory. Now I have some theories about why this happens, but in short, the auditory working memory task that we used, was very, very challenging. It was challenging even me going through the test. So I think there was some fatigue involved in that test, and that may be why we weren't able to really get significant improvements. So before we move on to key finding number five, I just want to present this information with the caveat that this testing was performed in a relatively small group of participants. We had a lot of different measures we were looking at, brain measures, cognitive measures, other measures I'll show you in a little bit.

And so we were kind of limited in group size. So this was just 21 participants with hearing loss. But if you look at other data coming out more recently, for example, Frank Lynn's group, out of Johns Hopkins University, they're showing very similar findings in their Achieve study, which was a randomized controlled clinical trial where they were able to measure significant improvements in cognitive function after treatment with

hearing aids. So I highly recommend taking a look at some of those larger scale studies, if you haven't already. Woo, gone through a lot today. Let's stop with key finding number five. So the fifth finding that has emerged from my research is that treatment of hearing loss, can improve other measures of overall health, functional outcomes and wellbeing.

So in this group of 21 participants with mild hearing loss, we administered several different outcome measures, one of which was, the International Hearing Aid Outcome Inventory, or IOI-HA. And this is a standardized questionnaire that gauges hearing aid outcomes, such as satisfaction with hearing aids, perceived benefit from hearing aids, hearing handicap, such as participation restrictions and activity limitations, improvements in quality of life with hearing aid use. And you can see across all of these different ratings of self-reported outcomes, very high ratings in our hearing loss group. So above four out of five on average across all these different subscales on the IOI-HA. So I think that this highlights, the importance of not just looking at auditory outcomes.

Does speech perception improve with hearing aid use, but also other measures of benefit from hearing aid use, such as quality of life? We also looked at auditory based outcomes, before and after treatment in our hearing loss group. So this is scores on the QuickSIN, a very commonly quick, easy to do five minutes speech perception and noise test. So before hearing aid use, before treatment with hearing aids in an unaided condition, our hearing loss group was scoring about 6 DB SNR on the QuickSIN, which is in the mild category, kind of a mild difficulty in background noise. And when tested at six months post-treatment with hearing aids, we can see a reduction in the QuickSIN score, which is better.

So a lower QuickSIN score is better. And within six months of hearing aid use, when tested in an aided condition, we can see a significant improvement in their speech and noise performance. And this improvement in speech and noise performance, can

translate not just to improved communication outcomes, but also things like improved quality of life as well. And finally, I just want to talk a little bit, about some preliminary data here. So in this same group of 21 participants with hearing loss, we used a measure called, the Center for Epidemiological Studies Depression Scale, and we administered this depression screening tool at baseline, and then at six months after hearing treatment, and we compared scores, on this depression screening tool at baseline between our hearing loss group and our normal hearing group.

So when looking at these depression scores, a higher score on this depression screener is worse. So a score that is equal to or above about 16, indicates that a person is at risk for clinical depression. So you can see that at baseline, scores on the depression screener between our hearing loss group and our normal hearing group were quite different. With individuals in our hearing loss group, on average, reporting significantly higher depressive symptoms, compared to our normal hearing group. And if we look at post-treatment effects. While depression symptoms improved, they decreased on average, after hearing treatment in our hearing loss group. It did not quite approach statistical significance, but just keep in mind that again, this hearing loss group, was individuals with mild hearing loss, not all severity categories.

So let's just take a minute and recap some of the themes from this research that we've talked about today. So first brain reorganization is evident, even in the early mild stages of adult onset hearing loss. Second, these brain changes come on really rapidly, within months of hearing loss onset. Third, treatment of hearing loss with amplification, can restore more typical brain function, can reverse some of those changes we see in cross-modal reorganization and changes in cortical resource allocation. Fourth, treatment of hearing loss can improve cognitive function, and we observe that across global cognitive function on that MoCA, that global cognitive screening tool, as well as in specific domains of cognitive function, such as processing speed, visual working memory, executive function.

And fifth, treatment of hearing loss can improve functional outcomes, communication outcomes, such as improved speech and noise performance, improved quality of life. And in some patients, though not on average, in this particular group that we looked at, may even decrease some depressive symptoms. Now, I'd like to just check in for a minute with you, with another poll question. So at the beginning of the webinar, I asked, what information are you currently using in your practice, to determine who's a good candidate for amplification, or to monitor treatment outcomes? I'd like to hear your thoughts now, on whether this presentation, has caused you to think a little bit differently, in terms of the way audiologists, could or might assess amplification candidacy and monitor treatment outcomes.

So go ahead and check your response and we'll take a look at the poll results. This is what I like to see. 89% of people said, yes, this caused me to think differently. 4%, no, 7% unsure. So when I think about evidence-based practice, I think of evidence-based practice as really this incorporation between research evidence, our patient's perspective, and our clinical experience. So I encourage you to reflect on what you've learned in this webinar today, to consider the strength of this research evidence and how you might or might not apply it, into your own clinical practice. So all in today with a couple of my thoughts, a couple of ways in which this research and research findings from other research studies, like the Achieve study out of Johns Hopkins, that I mentioned, that have really changed my way of thinking and my clinical approach to adult onset hearing loss.

So first, at the beginning of the webinar, I told you that hearing loss is more common than diabetes or cancer. And yet hearing screening is not routine practice in the adult population. Mammograms are recommended now beginning at age 40, for screening of cancer. Why not hearing screenings? How might we collaborate with other professionals, primary care physicians, allied health providers, to ensure earlier

screening of adult onset hearing loss? Second, as I showed you today, these brain changes happen really rapidly. And there's other research out there on things like hidden hearing loss. So early neural changes that take place, even before they are detectable on a conventional audiogram or conventional audiometric testing, with pure tone audiometry. And I think research has a long way to go in this realm before it can translate into clinical practice.

But what might audiology look like in the future? Could we use neuroimaging tools, brain-based methods and tools to identify adult onset hearing loss, signs of early neural degradation even sooner before these changes turn up on conventional behavioral tests of hearing. Third, the reality is that the average adult waits a decade with hearing loss before seeking treatment. I showed you the case study of the patient with sudden sensory neural hearing loss and how brain or reorganization was evident within weeks of hearing loss onset. But the average adult is not waiting weeks, not months. They're waiting decades, before they seek the help of a hearing health professional. So my question for you is, are we waiting too long to intervene?

By the time we introduce our intervention, hearing aids, cochlear implants, are we introducing our intervention, most likely, into a brain that is already substantially reorganized? We have one participant who asked, "What is being done currently to educate the medical community on the importance of early hearing loss detection and recommending annual hearing screening and tests?" This is a great question. There are several different researchers working on this, but I also know many audiologists out in the field, who are taking this into their own hands. So they're engaging in interprofessional relationships with primary care for providers, with nurses, and at primary care facilities to really educate the broader medical community on the importance of hearing screening and hearing testing in the adult population.

And I think that this is a sign maybe, that we audiologists, we need to get out of our offices. We need to broaden our reach and really be the ear experts and educate the medical community on things like the incidence and prevalence of hearing loss, the effects of auditory deprivation on cognitive function and other health outcomes. We need to be the advocates here in really raising awareness, both public health awareness and awareness within the medical community about this topic. Last, in order to better serve our patients, we really need to be considering the effects of hearing loss and the effects of hearing treatments beyond the ear. So yes, we are ear specialists, we love ears, right?

But we know that the implications of hearing loss are more far reaching and the potential benefits of amplification, do more than just improve communication, right? So we need to consider the effects on the brain, on the whole person. Moreover, I think that our messaging matters. When we are educating patients and motivating them to pursue treatments or to use their hearing technology, rather than a message like untreated hearing loss increases dementia risk. These messages that might scare individuals, even potentially prevent them from seeking treatment. What about treating hearing loss can improve cognitive health. Treating hearing loss can improve overall wellbeing? What if we flip it to more positive messaging? I got another question from a participant. She asked, "Do you feel that people need annual audiograms, or could it be more like every two to three years?

It seems like annual audiograms bogged down, some of the already overloaded schedules. What is your thoughts?" So my clinical professional opinion, is that maybe we shouldn't be using conventional audiograms for hearing screening purposes. A test that provides more real world evidence, of whether a patient is struggling is something like an unaided speech and noise test, something like the QuickSIN, because the QuickSIN is gonna tell us in a person's everyday life, are they struggling in background noise? So I think a lot of more research needs to be done in this area, but I don't know

that annual audiograms is the solution here. Another attendee said, "Perhaps a marketing campaign to educate consumers to ask their providers, for yearly hearing tests could help.

This is done for medications and appears to work, thoughts." So again, I think that there are different ways, that we could approach this topic, both from a clinical perspective and from a research perspective. But I come back to this idea that it starts with raising awareness, both in our patients and the larger medical community, from a public health perspective. So, I'll leave it there. I just wanna say, so those were some of my thoughts, but what are some of your thoughts? How might you decide as a clinical audiologist, to look beyond the ear in your own practice? And I just wanna say thank you for listening today and I'm open at this point, to answering any questions you might have, from today's presentation.

- [Christie] Thank you, Dr. Glick. For those of you who need to log out, that concludes the content portion of this presentation. And we do have just a couple more minutes here, that we can leave the classroom open. If there are any last comments or questions that pop up, feel free to place them in the queue and we can have Dr. Glick answer them, while she's still with us. In the meantime, Dr. Glick, I'd like to thank you for coming on and sharing your time and your expertise on this topic. It's a really important topic, just to think outside of the box, and we really appreciate that. This is not a question, but we do have a comment from an attendee and they just said thank you and that they totally agree with the positive framing.

Thank you for your comment.

- Yeah, thank you so much. See a couple other questions. Yeah, participant asked, "Do you think a similar pattern may be observed with conductive hearing loss in children with middle ear disease? This is an interesting question. I would love to look at this question in children. We have done this work in children with sensory neural hearing loss, and we do see these same patterns, cross-modal reorganization , changes in cortical resource allocation, in children with varying degrees of untreated hearing loss. I would expect that with a conductive hearing loss, we would also see similar changes. Conductive hearing loss is still a modification in typical stimulation of those neural pathways, just like sensory neural hearing loss. So I anticipate, that we'd probably see similar findings there.

Another participant asked, sorry if I missed this. Is there a way to connect with you? Yes, so you can find me at firstname.lastname, so Hannah, h-a-n-n-a-h.glick@unco.com, University of Northern Colorado. So feel free to reach out with questions at any time. Would love to talk with you, collaborate on research, et cetera.

- [Christie] And we are just gonna go ahead and close out the presentation today. There aren't any more questions in the queue, but just lots of thank yous. Dr. Glick, we appreciate it. This concludes today's presentation. Have a great day everyone.

- Thank you.