CDC, Division of Diabetes Translation

What No One Is Saying: The Impact of Diabetes on Hearing and Balance

Wednesday April 14, 2021

Transcript

Slide 1: Title Slide

Slide 2: Welcome

Betsy Rodriguez: Good afternoon and good morning to viewers in the West Coast, Alaska, and Hawaii. Welcome to our webinar, What No One Is Saying: The Impact of Diabetes on Hearing and Balance. My name is Betsy Rodriguez, and I am a senior public health advisor in the Division of Diabetes Translation of the Centers for Disease Control and Prevention.

Slide 3: Disclosure Statement

Before I introduce our moderator for today, I would like to go over some information about the webinar. At this time, we're required to share our disclosure statement. CDC, our planners, content experts, and their spouses and partners wish to disclose they have no financial interests or other relationship with the manufacturers of commercial products, suppliers of commercial services or commercial supporters. Planners have reviewed content to ensure there is no bias. The content presented will not include any discussion of their unlabeled use of a product or products under investigational service. CDC did not accept commercial support for this continuing education

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Slide 4: Continuing Education

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Slide 5: Please Note

Please note if you have never registered in TCEOnline, you will have to create a new account, and returning users should log in with their existing username and password. This webinar is being recorded, and an email will be sent out once the recording is available. The recording will also be approved for continuing education credit. This slides and transcript of the webinar will be made available with the recording.

Slide 6: Today's Moderator – Kathy Dowd

At this time, I am pleased to introduce our moderator for today's webinar, Dr. Kathy Dowd, executive director of The Audiology Project. Kathy Dowd is the executive director of The Audiology Project, working to raise awareness of the links between diabetes, hearing loss, and vestibular and risk of falls. She received her undergraduate [degree] in French at Spalding University in Louisville, Kentucky, in 1972; a master in audiology from University of Louisville in 1978; and a clinical doctorate from Salisbury University in 2008. Dr. Dowd's experience in audiology is in school education audiology, state agencies, ENT clinics, and private practice. Kathy, take it from here.

Slide 7: Setting the Stage: Diabetes and Ear Health

Kathy Dowd: Thank you so much, Betsy. The goal for our presentation today is to raise awareness and provide education on the links between diabetes, hearing loss, vestibular, and risk of falls. In this graphic, you can see the issues for hearing loss from microangiopathy and neural degeneration from diabetes. Symptoms of hearing loss are often invisible. So a valid screening will detect any hearing problem. We will also explore how diabetes impacts balance.

Slide 8: Audiology Scope of Practice

In this webinar, you will hear from audiologists who will share information on their scope of practice, as well as tips and strategies to help you in your work with people with diabetes or people who are at risk for developing type 2 diabetes.

Slide 9: Today's Objectives

The objectives for today's webinar are first to identify the underlying relationships between blood sugar management, hearing loss, and balance, as it relates to both prediabetes and diabetes; second, to explain the benefits of regular ear health screenings and education for people with diabetes as part of diabetes care and self-management, including through the provision of diabetes self-management education and support (DSMES) services, and in community or team-based clinical settings. Also, to utilize communication, education, and other strategies and resources for promoting screening for ear health conditions and for supporting people with diabetes, [or] for those who are at risk for type 2 diabetes, who already have hearing loss or difficulties with maintaining balance.

Slide 10: Have a Question for our Speakers?

During the webinar, if you have a question for our speakers, please type them in the Q&A box below. If you want to direct your question to a particular speaker, please feel free to note that in your

question. We will do our best to answer all questions during the Q&A portion of this webinar. If you have a question about obtaining continuing education credits, where to access this webinar once it's over, or other technical questions, please use the chat box feature.

Slide 11: Today's Presenters

I'm so pleased to present our expert panel. Dr. Patricia Gaffney, AuD. She is a professor of audiology at Nova Southeastern University in Fort Lauderdale, Florida. She teaches didactically and clinically in the specialty areas of vestibular diagnostics and treatment and amplification. She received her BA from the George Washington University and AuD from the University of Pittsburgh in 2005. Dr. Christopher Spankovich is an associate professor at the University of Mississippi Medical Center School of Medicine in the Department of Otolaryngology and Communications Sciences. He serves as the director of Clinical Research for the department as well as the director of Education for the Division of Audiology. He obtained his BA in psychology from the University of North Carolina at Wilmington, his master's in public health in behavioral science and health education from Emory University, and his AuD from Rush University, and a PhD in hearing sciences also from Vanderbilt University. Dr. Erin Piker is an associate professor and director of the Vestibular Sciences Lab in the Department of Communication Sciences and Disorders at James Madison University (JMU) in Virginia. Prior to her position at JMU, Dr. Piker spent four years as the director of auditory and vestibular research at Duke University Medical Center. She received her AuD from Vanderbilt University in 2008 and her PhD in hearing science with a minor in neuroscience from Vanderbilt University in 2012. Anjulyn Ballard, PhD, is an exercise physiologist and a recent graduate of Georgia State University. She is an ORISE (O-R-I-S-E) fellow in the Division of Diabetes Translation at CDC, and she's currently working in collaboration with partners and stakeholders on the programs and services that are under the National Diabetes Prevention Program. To start off, I would like to welcome Dr. Patricia Gaffney.

Slide 12: Overview of auditory and vestibular systems

Patricia Gaffney: All right, thank you for the introduction and thank you everyone for being here to listen to how diabetes and prediabetes can affect the auditory and vestibular systems.

Slide 13: Poll Question #1

So, how comfortable are you talking about ear health with people with diabetes or those at risk for diabetes? Not at all comfortable, a little comfortable, somewhat comfortable, very comfortable, or not sure? All right, so it looks like most people are somewhat comfortable and a little bit less there for all the other categories. So hopefully, at the end of this talk, you'll have some more information that you can share to be more comfortable talking about ear health and the risk for diabetes.

Slide 14: Infographics

So, infographics are a great way to visually represent information or data, and we know that they can help patients digest important information and remember it. There are many infographics available about the effects of diabetes on the body. Here are three examples. So, the first has a lot of information and calls out a number of body parts. The second one in the middle is short and sweet, hits the major areas, but doesn't give a lot of information, and the third here is a mix of both—a number of body systems and a little bit of information. So, if you look at all of them, they have things in common, such as they all hit on effects of the eyes, the feet, and the brain, but you'll notice that there's one thing missing.

Slide 15: Ears

And that one thing is the ears. So the warnings about the effects of diabetes on the ears are most often forgotten on infographics. I found one here. So, because it's missing from most infographics,

patients and caregivers are often unaware of the effects of diabetes on the ear. In this particular example, it does list the ear, and I know the print is very tiny, but it mentions the damage to the blood vessels can cause hearing loss. But the other thing is it doesn't really mention anything about vestibular loss.

Slide 16: Hearing Loss and Diabetes in the United States

So, let's look at some basic epidemiologic data. There are approximately 122 million adults in the United States that have diabetes or prediabetes, according to the 2020 National Diabetes Statistics Report. Additionally, there are 37.5 million adults that have some degree of hearing loss. So, there is an overlap of these two groups, but are they intertwined or are they just coexisting issues?

Slide 17: Link Between Diabetes and Hearing Loss

So, the *Bainbridge* study of 2008 used epidemiologic data from the National Health and Nutrition Examination Survey (or the NHANES database), from 1990 to 2004 to evaluate hearing loss and diabetes status. Their study looked at adults between the ages of 20 and 69, and they found a higher odds ratio—1.82—of having hearing loss in the diabetes population, and this was regardless of age, sex, race, ethnicity, or education level.

Slide 18: Odds Ratios from Studies for Participants with Hearing Loss and Diabetes

Horikawa, et al. in 2013 performed a meta-analysis of studies of diabetes and hearing loss. They used 13 studies which had a pooled participant number of 20,194. They concluded that there is a higher prevalence of hearing impairment in patients with diabetes, compared to patients without diabetes, regardless of age. The figure shown here is a forest plot of odds ratios of hearing impairment for participants with diabetes compared to those who do not [have diabetes]. There

was a consistent positive association between diabetes and hearing impairment. In this graphic here, the size of the squares represents the statistical weight of each study. The pooled odds ratio is indicated by the unshaded diamond at the bottom, which shows an odds ratio of 2.08. This suggests that hearing impairment is more prevalent in those with diabetes than adults without diabetes.

Slide 19: Falls and Diabetes in the United States

So, going back to our statistics from earlier, we had 122 million adults who have diabetes or prediabetes, but we also have 36 million people, adults, who have falls per year. So, one risk factor for falls is vestibular dysfunction. So, let's take a little bit more of a look at those statistics.

Slide 20: Vestibular Loss, Falls, and Diabetes

So, I highlighted just a few articles here to illustrate the overlap of vestibular dysfunction, falls, and diabetes and prediabetes. *Li et al*. in 2019 found a statistically higher number of caloric and postural abnormalities in patients with diabetes, and calorics is a test that we use for vestibular testing, which analyzes a portion of the inner ear for function. *Chen et al*. in 2020 performed a systematic review and meta-analysis on benign paroxysmal positional vertigo or BPPV, which is a common otologic condition causing vertigo. They found that diabetes patients had a significant factor and showed a high odds ratio of 2.62. *Walley et al*. in 2014 evaluated postural testing methods and found diabetes patients had more postural abnormalities. And finally, *Agrawal [et al.]* and colleagues in 2010 found a higher odds ratio for vestibular dysfunction in older adults, and Dr. Piker will talk a little bit more about that a little later.

Slide 21: Poll Question #2

So, we have a second polling question. What is the role of the audiologist? Is it to assess hearing and balance function, perform surgery on the ear, prescribe medication related to ear infections, or all of the above? Okay, so the majority of people stated assess hearing and balance function, and a small percentage said all of the above. So, the letter A, assess hearing and balance function is correct. We do not perform surgery or prescribe medication.

Slide 22: Audiologists

So, I just wanted to talk a little bit about who an audiologist is. So, audiologists are masters or doctoral level non-physician health care providers. As of 2007, the minimum degree for audiology is a doctoral degree, and clinical audiologists hold an AuD or Doctor of Audiology. Audiologists evaluate, treat, and manage hearing loss, tinnitus, and vestibular disorders, and audiologists can be found in a number of work settings.

Slide 23: Professionals Who See Those with "Ear" Complaints

So, I just want to clarify how audiology fits into the professional space as far as who sees patients with ear complaints. So first off, otolaryngologists. Otolaryngologists, or ENTs, are physicians that see patients to treat medical conditions through medication or surgery, such as ear infections, tumors, or other diseases. Audiologists, as we discussed before, are non-physicians with master's or doctoral level degrees to evaluate hearing, tinnitus, and vestibular dysfunction, and hearing aid dispensers (or hearing instrument specialists) are generally individuals who can test hearing and fit hearing aid devices. In some states, they are allowed to evaluate tinnitus, but they cannot evaluate vestibular function, and they cannot evaluate children. The minimum level of education is a high school diploma.

Slide 24: Ear Anatomy and Physiology

So, I'm going to talk a little bit about the anatomy and physiology of the ear, so we're all on the same page. The ear is divided into three main sections. The first is the outer ear. This starts with the pinna aka the earlobe, goes through the ear canal up to the tympanic membrane or the eardrum. So, sound travels down this ear canal to vibrate the tympanic membrane. From there we have the middle ear. The middle ear is the tympanic membrane through the ossicles. So, the tympanic membrane vibrates, which then in turn vibrates the three ossicles—our malleus, incus, and stapes, and then we get to the inner ear. So, the inner ear is comprised of two sections. We have the vestibular section and the cochlear sensory section. The inner ear is fluid filled, and the stapes pushes on the membrane, the oval window, to move that fluid.

Slide 25: Inner Ear – Cochlea

So here, we see a picture of the inner ear, if we were to slice through it. The cochlea is the sensory part of the hearing system. The inner ear is fluid filled, and the stapes vibrates the oval window, which moves the fluid in the cochlea. The small hair cells and the organ of Corti bend with the fluid movement, and this stimulates the nerve underneath, sending the signals through to the temporal lobe of the brain. The structure of the inner ear is a very delicate and small system. The whole inner ear is roughly the size of a penny. With diabetes, we know that there are systemic changes and damage to the blood vessels, and this, in turn, can damage the blood supply to the cochlea. Our cochlea gets blood from the anterior inferior cerebellar artery or the AICA—and so any disturbances to our stria vascularis, which is where the blood flows to, can change function in the inner ear.

Slide 26: Cochlea Images

So, I always like to bring up these two pictures here. So, the picture on the left is a healthy cochlea, and you see that there are three rows of hair cells towards the bottom. Those are our outer hair

cells, and we have one row at the very top, which is our inner hair cells. You'll notice that they're all nicely organized and aligned and in a consistent pattern. In the picture on the right, however, this is the cochlea of someone who has hearing loss. The outer hair cells are missing in spots or damaged or misaligned. The inner hair cells are disheveled and completely disorganized. In these two pictures, you can see the stark reality of hearing loss. Once these hair cells are gone or bent, they will never go back to their original organization, and the hearing loss is permanent.

Slide 27: Hearing Loss

There are three types of hearing loss. First is conductive hearing loss: this is hearing loss caused by an abnormality of the outer or middle ear. This can be something as simple as ear wax or more significant like a middle ear infection or otosclerosis. Typically, conductive hearing losses can be treated through medication or surgery. Next is sensorineural hearing loss, which is a hearing loss caused by damage to the cochlea and or the auditory nerve. This hearing loss is generally permanent, and therefore it is treated with hearing aids and or cochlear implant, if the hearing loss is severe enough. [The third type of hearing loss—] mixed hearing loss, is a combination of a conductive component and a sensorineural hearing loss. In many cases, the conductive component can be treated through medication or surgery, but there's still an underlying sensory loss. With diabetes, what we are mostly talking about is sensorineural hearing loss. Therefore, the damage to the auditory nerve in the cochlea is going to be permanent and generally progressive over time. With diabetes, the change in hearing would be gradual, and patients may not be aware of the loss until it is more significant.

Slide 28: Vestibular

So, let's switch gears and talk a little bit about the anatomy [and] physiology of the vestibular system.

So, the other half of the inner ear is the vestibular portion of the inner ear. This is the end organ that senses where we are in space. There are three semicircular canals. We have the anterior, often called the superior; we have the horizontal, also called the lateral; and the posterior, also called the inferior. We also have two otolith organs, the utricle and the saccule.

Slide 29: Inner Ear – Vestibular

Our three semicircular canals detect rotation and angular movement based on the fluid moving in the canals, deflecting the cupula and the underlying hair cells. You see that in the left picture, the cupula is centered over the hair cells at the bottom, and as the fluid moves, the hair cells bend creating a response. In the right picture, it depicts the otolith organs, the utricle and the saccule. Both of these detect gravity, linear acceleration, tilt, and centrifugation. The otolith has a membrane with calcium carbonate crystals called otoconia sitting on top. As the weight of the crystals shift, it stimulates the hair cells underneath, causing a response. Abnormalities of either one of these can cause dizziness, vertigo, unsteadiness, imbalance, or tilt.

Slide 30: Vestibular Pathway

Benign paroxysmal positional vertigo is one common cause of positional vertigo caused by the otoconia coming out of the utricle and going into one of the semicircular canals. So, how does all of this relate to falls? To keep upright and balanced, there are three systems that are working together. We have vestibular, vision, and somatosensory. From the ear, there are neural projections that drive the eyes and the vestibulo ocular reflex, or the VOR pathway, to keep vision stable when we move. There's also communication to and from the cerebellum to help with motor movement and coordination. And additionally, there are projections from the ear that go down the vestibulospinal tract to coordinate posture and movement across the body. Knowing that

diabetes also causes retinopathy and neuropathy, we can see that this is a perfect storm of fall risk issues when multiple balance systems are impaired.

Slide 31: Key Takeaways

So, just to wrap up a few key takeaways. As shown in the infographics, the ear is often not listed as a possible abnormality related to diabetes. So, health care providers need to [could] talk about these issues with their patients and make appropriate referrals, and for those referrals, audiologists would be the best choice for hearing, tinnitus, or balance testing. Finally, because these changes to the inner ear are permanent, prevention is key through blood sugar management and monitoring ear status through regular hearing evaluation and monitoring for balance or falls.

Slide 32: References

There are a few articles referenced here if you'd like to check out some more data, and now I would like to turn over the presentation to Dr. Christopher Spankovich.

Slide 33: Diabetes and Hearing

Christopher Spankovich: Thank you, Dr. Gaffney. Wonderful lecture, very helpful for mine as well.

Slide 34: Poll Question #3

So, I'm going to start with a poll question, and my poll question is, is hearing loss inevitable? Yes, no, or unsure? And while you're answering that, I'm going to move to the next slide.

Slide 35: Modifiable and Non-Modifiable Factors

Hearing loss, like most sensory systems, is prone to damage from modifiable and non-modifiable factors. For example, currently, we cannot modify our genetics, yet, however, we can modify our risk for hearing loss related to noise exposure and medications that can cause damage to the inner ear that we call ototoxic medication. Though there is some level of hearing loss that we can expect with age, particularly in the higher frequency range above the levels that are critical for speech understanding. So, [while] humans can hear from about 20 to 20,000 hertz, frequency ranges above 8,000 hertz don't have a lot of critical elements to hearing loss or critical elements to speech understanding, but indeed, that's where we can see the earliest effects of age. The area important for speech, though—damage there is not necessarily inevitable. So, as I saw from our poll there, it was about a good split in terms of people that think hearing loss is inevitable versus not. Well, it's not, particularly for at least frequency range [that is] important for speech understanding. Rather, hearing loss is dependent on our lifetime of noise exposure [and] our lifetime of different medications that may have ototoxic properties, as well as our health. So, our cardiovascular health, our metabolic health, and our neurological health all contribute to the hearing loss that we acquire as we get older.

Slide 36: Ear Graphics

In this next slide, we see in A [an] image similar to what we observed from Dr. Gaffney, and so where we're going to see predominant effects of diabetes on the auditory pathway is at the cochlea level, the inner ear, and in B of this image, we can see where we slice through the cochlea, and we see in C now a close up view of one portion of these little chambers within the inner ear called the scala media. This is this central portion here. Understand that the physiology of the cochlea is highly prone to the effects of diabetes because it is a highly active, metabolically demanding organ. The function of the cochlea requires a constant recycling of potassium through the pathway to serve as a battery to be able to maintain the amplification of the system

provided by those cells that Dr. Gaffney was mentioning, the outer hair cells. These outer hair cells have motility, meaning that they can move up and down and add amplification to the system, and by doing so, they then stimulate another set of cells to then stimulate the auditory nerve, and so we can hear. The primary energy source for this system is indeed glucose, and so glucose is supplied to the inner ear by the blood supply to the stria vascularis. Changes in your blood levels of glucose, are also mirrored within the inner ear, though there can be a little time delay there. Insulin also exists within the inner ear but does not lead to have a primary role in the regulation of glucose, but rather in protein synthesis and signaling pathways.

Slide 37: Inner Ear Animation

In the next slide, we can see an animation of the inner ear functioning, and here we can see those outer hair cells moving up and down, and we can also observe then, on the left-hand side of that picture, the inner hair cell being activated. That releases a neurotransmitter called glutamate into the synapse, stimulates the auditory nerve, and sends that signal up to our brain where we hear.

Slide 38: How Does Diabetes Cause Damage?

So, how does diabetes cause damage to this pathway? Well, one way indeed is through microangiopathy, so the changes in vascularization to the inner ear. However, there are other effects as well, including mitochondrial dysfunction, advanced glycation end products, inflammation, glutathione dysregulation, protein synthesis dysfunction, and glutamate excitotoxicity. Where we observe these primary effects is going to be in these different regions of the cochlea on the next slide.

Slide 39: Cochlea Image

So, we can see where we have red areas here, the stria vascularis, the outer hair cells themselves, and then particularly the synapse supplying the inner hair cell and then the neural supply to those that's going to those synapse—that is going to be the area of predominant damage relative to diabetes. We'll explore this a little bit more closely with an example.

Slide 40: Example

So here we see an image with hair cells, and these are actually inner hair cells. In A, we can see a hair cell that is stressed, okay? Let's say that there's a noise exposure. What happens as a result of that noise exposure is generation of free radicals, in particular, superoxide, peroxynitrite, as well as hydrogen peroxide. And these free radicals will damage the integrity of the cell, potentially cause cellular apoptosis, cell death. In B, luckily, our cells have some ways to battle these free radicals. So, one, there are endogenous antioxidants, antioxidants our cells make such as glutathione. As we just heard in the previous slide, diabetes can cause glutathione dysregulation. We can have other factors as well, such as exogenous antioxidants that we get from our diet that can help protect our inner ear. However, if a person has a poor diet, that might affect the availability of those exogenous antioxidants. So, if the cell is able to fend off these damaging pathways, it can stay in homeostasis, and it can survive. So, it'll stay at B; however, if it's overwhelmed, then C can occur, where we begin to see damage to the membranes of the cell and the cell wall, as well as damage at the level of the synapse that we call synaptopathy or glutamate excitotoxicity, damaging those synapses.

Slide 41: Figures

In the next slide, we can observe here some figures representative of human temporal bone studies, and from this, what we can observe is that there can be changes to the inner ear across the spectrum of the cochlea. So, realize again, we hear from 20 to 20,000 hertz, but not the entire

cochlea responds to every frequency. Rather, if we uncoil that cochlea, it'd be laid out like a piano, except the higher frequencies would be near the middle ear and the lower frequencies towards the apex coil. In this first figure to the left, what we can observe is that strias area, that stria vascularis area, we can see atrophy in that area, but that atrophy appears to be in the more lower frequency portion of the cochlea, the apical portion of the cochlea. In the middle figure, we can see loss of outer hair cells, but where we see the greater loss of outer hair cells is actually in the opposite portion, in the basal portion of the higher frequency portion. So, this might be related to differential effects of diabetes on the auditory pathway, and that can be represented in the final figure to the right-hand side that's showing hearing testing across different age groups and where diabetes has its effect. And where we see the greatest effects is in the higher frequencies and then also in the lower frequencies. It's just that these higher frequency effects and damage are likely related more to noise exposure, and related to glutathione dysregulation, related to greater susceptibility to damage, related to free radicals and glutamate excitotoxicity, whereas the lower frequency damage we see here is likely more relative to the microangiopathy.

Slide 42: Recap: Summary of Literature

So, in summary, overall, the evidence indicates that there is a significant relationship between diabetes and hearing dysfunction. There's human as well as animal-based data to help support this, and a major thing to walk away with is this: that we can see these differential effects of diabetes along the cochlea, along the frequency range that humans can hear, and a key thing that can occur with all this is earlier onset of hearing loss. Rather than seeing hearing loss effects in the 50s and 60s as a person ages, we can see in persons with type 2 diabetes earlier onset of hearing loss in the 20s and 30s.

Slide 43: Screening and Diagnosis

Next, we're going to switch topics and talk about screening and diagnosis. What do we need to do to sort of screen individuals if they're having hearing difficulty? How do we make a diagnosis of that?

Slide 44: Diagnosis

So, the most common type of hearing loss, as Dr. Gaffney already mentioned, related to diabetes is going to be sensorineural hearing loss. This is going to be damage to the inner ear, sensory, and neural receptors. There is limited data to support [the idea] that diabetes can cause conductive hearing loss, but individuals with diabetes are at general increased risk for infections. So, we want to rule this out. Mixed hearing loss, as we heard, is a combination of these two things. We also need to consider tinnitus. Individuals with diabetes are at increased risk of reporting tinnitus, and tinnitus is a perception of ringing or buzzing in the ears.

Slide 45: When to Screen: Considerations

So, when do we screen and how do we screen? Well, it is our general recommendation that we want to screen as soon as possible after identification of diabetes, but we need to be cognizant that the diagnosis can be overwhelming for the patient, and that they have other things that they're dealing with as well. But our screening can start with some simple questions, and [we should] be aware that a person with diabetes can develop hearing loss earlier in life, and there are tools for reducing progression and for prevention. There are also high-risk considerations we need to be aware of. If a person has tinnitus, then they should [could] likely be referred to audiology for a hearing assessment. If they complain specifically of hearing difficulty and noise, [that's] another reason. If they have a job or occupation or activities or hobbies that are high noise exposure, again, they should [may] be referred. If they have a history of ototoxic drug use—these include

aminoglycosides, platinum-based chemotherapies, even furosemide, particularly if it's delivered intravenously— they should be monitored over time while they're on those drugs. Now, I will point out also the importance of our ENT colleagues. If the patient presents with a sudden hearing loss, if they're reporting ear pain, if they have drainage from their ear or blood and pus coming from the ear, these are reasons to refer to the otolaryngologist—to the ENT, because those can be medical issues. But the vast majority of hearing issues you're going to see with the diabetes population are not going to be medically treatable. It's going to be under the scope of the audiologist and counseling and use of amplification and aural rehabilitation strategies and management.

Slide 46: Screening Recommendations

Okay, so how can we screen? So, some basic questions can help us screen, and those are listed here. Just asking the person, do they feel like they're having any hearing difficulty, or does their family perceive that? Have they ever had their hearing tested before? Beyond asking questions, you can actually purchase little screening tools. An example is here—where this device here will, when you press a button, will play a tone to the ear. If the patient hears it, then they pass, and if they don't, then they likely need a referral for a diagnostic evaluation. What we recommend for a diagnostic evaluation is a comprehensive audiological evaluation, and this next slide shows what that looks like.

Slide 47: Diagnostic Recommendations

We can observe here an audiogram to the right. So, this is a hearing assessment that we will perform, and this is when you raise your hand when you hear the beep. We can do other tests as well, but this is one of our primary tests, and this should [is recommended to] be performed at least

every two years or annually, or even more often if there are higher risk factors. So, for example, if they were on an ototoxic drug.

Slide 48: Diagnostic Considerations

There's other testing we can do, including extended high frequency testing, OAEs [otoacoustic emissions], auditory evoked potentials, tinnitus assessment, and even if a person has normal hearing sensitivity, they could still have hearing difficulty, which can be an indication of a central auditory processing issue, which is another thing that we can assess.

Slide 49: Recap

So again, the most common type of hearing loss is diabetes—I mean—is sensorineural loss related to diabetes. Asking simple questions can be helpful in screening. We recommend a comprehensive audiological evaluation upon the diagnosis really to establish a baseline and from there, every couple of years or more often, depending on high risk factors.

Slide 50: Prevention and Treatment

So finally, we're going to move into the topic of prevention and treatment of hearing loss.

Slide 51: Prevention 3x3

So, when we think of prevention and treatment, we think of primary, secondary, and tertiary. Primary is going to refer to that we're preventing a hearing loss from occurring at all. Secondary is that we're going to get some early evidence of that and then try to prevent further progression, and tertiary is that they have hearing loss, and we're going to try to intervene for the issues that they're having, the hearing difficulties that they're having.

Slides **52/53: Prevention: Direct and Prevention: Indirect**

So, we want to start with patient counseling. Persons with diabetes have greater susceptibility to acquired hearing loss. So, this can be utilization of hearing protection devices when around a loud sound; turning down the volume on the iPhone or whatever loud music they may listen to in the car; recognize that if they're on ototoxic medication, they do need to have careful monitoring; and letting the patient understand and know that they could have an earlier onset of hearing loss. And one way to recognize this is decreased understanding of speech, particularly in noisy backgrounds. Second, the evaluation establishing a baseline hearing test is critical for us to monitor hearing and monitor changes over time as well as to implement further counseling. And this further counseling can include topics that diabetes educators work [on] with their patients all the time, and this can be talking about physical activity, talking about nutrition.

Slide 54: Healthy Eating Index

So, here is an example of that. This is some of my own work, and what this is showing is the Healthy Eating Index, and what we can see here is that persons that have healthier diets have better hearing. And so this is important to recognize that the ear is not separate from the rest of the body. And just like the changes that you recommend to your patients to help their overall health, [these changes] can help their hearing health. As audiologists, we should also be involved in helping [inaudible] diet patients with diabetes by discussing the importance of their ABCs.

Slide 55: ABCs

Just like what diabetes educators bring to the mix, we want to be sure to be on our side reinforcing those concepts with the patient.

Slide 56: Aural Rehabilitation Strategies

Other things that we can talk about are aural rehabilitation and communication strategies, and this can enhance the patient provider interaction as well. If your patient has hearing loss, they may have difficulty following the recommendations that you're giving them. So, you can look into having assisted listening devices in the clinic. This includes something like a pocket talker or just using simple communication strategies as listed here: facing the speaker, using clear speech, reducing background noise—all very helpful things.

Slide 57: Management

If the patient does have hearing loss and you refer them over to audiology, ways that we can manage that hearing loss include hearing aids, and this can be complete with individuals with slight to even profound degrees of hearing loss. But if there's even more severe to profound degrees of hearing loss, so they're not getting benefit from amplification, a cochlear implant may be something that is an option.

Slide 58: Recap: Diabetes and Hearing

So finally, with diabetes and hearing, prevention is the key. We want to help the individual not only preserve their hearing health but also their overall health, and so diabetes management is key for hearing health. Talking to the patient about reducing noise exposure [and] wearing hearing protection devices when in loud noise exposures is important. Early identification is key. So, getting a referral over to audiology, so we can establish some baseline measures. And monitor[ing] things is important. And then finally, management, aural rehabilitation, communication strategies, the use of hearing aids and other amplification devices, and improved access is critical for this patient population.

Slide 59: Any Questions?

If you have any questions, you can either put it into the Q&A, and I'll be happy to address those later or you can email me at cspankovich@umc.edu, and now I will turn it over to Dr. Erin Piker.

Slide 60: Diabetes and Balance

Erin Piker: All right, thank you, and it's a pleasure to be with you all today. So, this next section is going to be on diabetes and balance, but my research is on the vestibular sensory system, which is one we're not typically conscious of. We're usually unaware of it until it stops working correctly. In a more sudden acute case, this can cause vertigo, and symptoms can be very severe. But in more gradual cases, like what we would see with aging or what I would expect with something like diabetes is symptoms are often manifested as our balance. So, we're going to talk about balance with a focus on risk of falls.

Slide 61: Risk of Falls

So, these are some falls facts right from the CDC. Each year, 3 million older adults are going to be treated in the emergency department for falls injuries. As many as one in three adults over 65 fall; however, only about 50% tell their doctor, and one out of five falls can cause a serious injury. The most serious are often broken bones, such as a hip fracture or a head injury, such as a traumatic brain injury. Falls are also costly. They're not just costly to individuals and their body but also to society. In 2015, the total medical cost for falls was over 50 billion, and many who fall, even if not injured, can become afraid of falling.

Slide 62: Risk Factors for Falls: **Extrinsic and Intrinsic**

So, remember, if one out of three fall but only half tell their doctor, this is an issue, because a fear of falling could cause a person to become less active. When that happens, they can become weaker, and when that happens, that can increase the risk of falling. So, there's a lot of things

that can put someone at risk for falls. The CDC also has some fact sheets here on risk factors for falling. Most falls are going to be caused by an interaction of multiple risk factors, and they can usually be divided into either extrinsic things—those are things in your environment, so it could be dim lighting or a slippery surface, and then intrinsic. And in the population I work with, my patients are often advanced age. They've either previously fallen, or they have a fear of falling, and many have chronic conditions, but all of them are seeing me because of a gait or balance problem. The more risk factors a person has, whether extrinsic or intrinsic, the greater their chance of falling. So it's important to reduce risk factors, because that will lower the chances of falling, and to do that, we need to be aware of the risks.

Slide 63: Risk Factors for Falls

So, on the next slide, I'm just sort of focusing here that one of the major factors that contributes to gait and balance problems is going to be a vestibular disorder, and Dr. Gaffney touched on this. Fortunately, vestibular disorders and/or poor balance are one of the risk factors for which an effective intervention exists.

Slide 64: Poll Question #4

Poll question time. So, how often do you talk about risk of falls with people with diabetes or those at risk for diabetes? Never, rarely, sometimes, always, not sure? So, pretty close between rarely and sometimes, always, was around 20%, okay. Well, then hopefully you'll have a little bit more information after today's webinar.

Slide 65: Risk of Falls and Vestibular Impairment

So, risk of falls and vestibular loss. Dr. Gaffney introduced this topic today, and I'll spend the next few slides elaborating on how vestibular loss itself is a risk factor for falling, also how diabetes is [a

risk factor], and then how the combination of the two can be dangerous for our patients, and then I'll end with some action items that we can take away. So, there are multiple risk factors for falling, but one of the major ones is going to be things like difficulty walking, slower gait, feeling off balance, and the vestibular system senses motion of the head, and when the system isn't working correctly, we're going to have inaccurate input to the brain regarding head movement. Where this often shows up the most is when we move our heads the most, which is usually when we're walking upright and trying to maintain our balance. So, a vestibular impairment can no doubt result in imbalance, longer slower steps, abnormal gait, [and] dizziness when walking. And there's compelling evidence from large population-based epidemiologic studies that a vestibular impairment is itself an independent risk factor for falling and can actually increase the odds of falling twelve-fold. So, vestibular loss and risk of falls is a huge issue. The very first research project I ever worked on as a research assistant was this paper here. It's now, I think, 14 years old, but it's still relevant, and what we did was we looked at close to 200 patients who were referred to our multifactorial risk-of-falls clinic—and everyone had multiple risk factors, mainly advanced age or previous falls or multiple medications. But what was surprising about the data set was [that] 73% had an undiagnosed vestibular impairment that had gone untreated.

Slide 66: Risk of Falls and Diabetes

So, let's connect this to diabetes. In the list of intrinsic risk factors from the CDC, diabetes was included in the column of chronic conditions that could put one at risk for a fall, and diabetes is also an independent risk factor for falling. And a recent meta-analysis, looking at diabetes for risk of falls in older adults, reported that the annual incidence of falls in elderly persons with diabetes was 39%. So, nearly four out of 10 will fall in a given year. Remember, only half of patients are telling their doctor when they fall, and so the actual number may be higher. The reasons for this are going to be multifactorial. For example, there's going to be the issue of multiple medications,

which is going to be common in our patients with diabetes and is also a falls risk. But in terms of sensory function, the effects of diabetes on balance can be described as this perfect storm analogy, because the pathophysiology of diabetes can result in detrimental effects in all three sensory systems that we need for gait and balance. So, that's vision, proprioception, and vestibular.

Slide 67: Sensory Systems

So, we not only have a patient population with possible multiple medications and other risk factors for falls, but we have this perfect storm of sensory issues that may lead to a fall or fear of falling. So, this is sort of a review of that perfect storm analogy. To maintain our balance, we need all these sensory systems. We need our vision, we need proprioception—particularly a sense of touch in our feet, and the vestibular system, and all of this is going to be coordinated and integrated in the central nervous system. In a patient with diabetes, particularly those with a long duration of the disease, there's a potential for all three of these, as well as the central nervous system, to be affected.

Slide 68: Diabetes and Vestibular Pathology

And we have a lot of research on the effects of diabetes on vision and on proprioception, and we know a lot about retinopathy, and we know a lot about peripheral neuropathy, and there's public awareness campaigns that are going to alert our patients to this. And if you're working with a patient with long duration and [a] severe form of the disease, you would probably immediately refer to get their eyes and feet looked at, but this third component, vestibular, is far less studied. There's been a little bit of animal work exploring some vestibular deficits, and a lot of the pathophysiology that Dr. Spankovich talked about in the auditory system we're going to see in [the] vestibular system—and so I saw his slides, and I chose not to go over all of that. I want

to focus on some of the more clinical studies and particularly some of the large population-based epi studies that really raised the issue of diabetes, vestibular loss, and risk of falls. And one of the first big ones was 10 years ago, and it was from the National Health and Nutrition Examination Survey, the NHANES survey that Dr. Gaffney mentioned. So, they investigated the relationship between diabetes, vestibular function, and their evidence was very compelling. So, out of a sample of over 1,100 adults over 40, 17% had diabetes. Of those with diabetes, mild peripheral neuropathy was in 19%, severe was less common in 7%. Mild retinopathy was common in 54%, severe retinopathy in 22%, but the vestibular dysfunction, which is less studied and less tested for, was reported in 54% of patients. And so, it was just as common as mild retinopathy, and they also estimated the patients with diabetes were about 70% more likely to have a vestibular loss compared to their age matched controls, and for those with diabetes and vestibular function, the risk of falls was twice as high. So, we've got these very convincing large-scale epidemiologic studies alerting us to the high prevalence of vestibular dysfunction and people with diabetes with this two-fold increase in falls risk. But in terms of clinical studies, they're a little bit more–less compelling evidence.

Slide 69: Diabetes and Vestibular Pathology

Vestibular anatomy and physiology are very complicated, and testing the system is very difficult because of the way it's housed within the temporal bone, and it takes specialized equipment and training. With that being said, we do have some smaller clinical lab studies that have attempted to look at vestibular dysfunction in patients with diabetes to better define this issue. Is there a pattern of loss? Is it mild? Is it severe? Is it peripheral? Is it central? And so, some have looked at the semicircular canals specifically (and Dr. Gaffney went over vestibular anatomy), but the semicircular canals sense angular motion of the head, and we have three of them on each side, so we have six total. And some studies suggest these can be adversely damaged by diabetes and

others suggest they're not. Meanwhile, there's some studies looking specifically at our otolith organs, and so those are the ones that are going to sense linear motion. You can see in this picture, one's [for] bending down, and the other one's more for going frontwards and backwards. These are also our gravity preceptors, and we sometimes see decrements in these parts of the vestibular system with diabetes, and oftentimes, we see conflicting evidence between these two things where maybe a specific reflex test will show one thing, and then a more functional test shows something else. But what we do see is an overall decrease in balance and the function needed to maintain balance, and then this last point here probably the most consistent between studies is on BPPV, and Dr. Gaffney also introduced what benign paroxysmal positional vertigo (BPPV) is. Many listening have probably had this, and as far as vestibular pathologies go, this one is relatively common, but it's going to occur in the otoconia that are normally sitting on the otolith organs, giving them some weight, allowing them to sense linear movements and gravity. But they break free, and they fall into one of the semicircular canals where they don't belong. It becomes a problem if you move your head, and you can get this brief sensation of vertigo. BPPV is no doubt more common in patients with diabetes, and that's been shown in epidemiologic studies and in clinical studies and in temporal bone studies. BPPV alone can cause a fall. It's also very easy to identify, and it's very easy to treat.

Slide 70: Diabetes, Vestibular Pathology, and Risk of Falls

So, I'm going to finish by going over some easy screenings we can all do, but here's a quick brief summary of what we know so far about diabetes and vestibular pathology and risk of falls. Patients with diabetes are 70% more likely to have a vestibular impairment. The exact nature of that impairment still remains elusive. The clinical lab studies haven't caught up yet, but data from NHANES and others suggest that vestibular loss independently increases the odds of falling in patients with diabetes more than two-fold, and this is after adjusting for peripheral

neuropathy and vision issues. Patients with diabetes are also more likely to develop BPPV, and we have pretty strong consistent evidence for this. An interesting finding in the BPPV literature is that diabetes doesn't just cause more BPPV to occur, but it also causes more frequent recurrence of this type of vertigo. However, if blood sugar is controlled, this risk decreases. So, the association is reversible, and these numbers and rates of BPPV are largely driven by individuals with longer duration of the disease and those with higher A1C levels. So, duration and severity of the disease matters, and better controlled diabetes will reduce all of these risks. So, awareness of this issue is warranted, as is a screening.

Slide 71: Vestibular/Balance Screening Strategies

So, screening strategies. Currently, there is not enough evidence to suggest everyone with diabetes needs to have an extensive vestibular workup, right. We have less evidence relative to the auditory system, and it's relatively easy to get to hearing tests, whereas it's more difficult to get an extensive vestibular evaluation. But screenings that are simple, brief, and inexpensive and can lead to a known effective treatment is what I'd recommend. So, these are some examples of functional screenings. By function, I mean looking at overall balance, and it can be something like a quick assessment of balance, like the Romberg on foam, and this is the assessment done by the NHANES study. It's a very simple screener. It doesn't require training to administer, but basically, there's four 30-second conditions of balance. This picture is illustrating the fourth condition, which is the hardest condition, the most vestibular taxing condition, where the eyes are closed and the person stands on a piece of foam. Ignore the Google Glasses on this picture. This is from my lab, and the Google Glasses were for something else, but if someone cannot stand on foam with their eyes closed for 30 seconds, it's highly suggestive of a vestibular disorder.

Slide 72: Vestibular/Balance Screening Strategies

So, that was the Romberg on foam. That's a static balance measure. All you have to do is stand for 30 seconds. Another simple functional balance measure that looks at more dynamic movements is called Timed Up and Go (TUG), and the CDC has a PDF of how to conduct this screener to assess mobility. The website is here, and it's also on the list of resources at the end of these slides. Timed Up and Go doesn't require any training to administer either. You basically need a chair, a space of about 10 feet in front of the chair, and a stopwatch. Of course, now we'll just use our phones, and we won't even need stopwatches anymore. So, that's an easy screen.

Slide 73: Vestibular/Balance Screening Strategies

Another screener—and Dr. Spankovich touched on this—is just a simple question, just asking, "have you fallen or do you have a fear of falling?" If they say yes to those two things, they're at risk for falls. There are also many validated questionnaires for vestibular loss, but I'm recommending one here that I worked on with some colleagues at Vanderbilt University, and it's called the Dizziness Symptom Profile (DSP). It's 31 questions; it's a Likert scale. It takes a few minutes to fill out, but it's going to screen for the seven most common vestibular diseases. But I recommend it for this population because it includes BPPV, and the link to the DSP is here. It's also in the list of resources at the end of these slides, and in that link is the form as well as a spreadsheet where you can put in their answers, and a bar graph is spit out, showing you if the person scored high in one of the subscales. So, I would look at the BPPV subscales specifically. And then finally, counseling and providing information could make a big difference. I think an awareness campaign like we see for all sorts of issues can make a big difference. You can reduce the effects of diabetes on the vestibular function and reduce your risk of falls, if you know that the risk is there.

Slide 74: Key Takeaways

So, in summary, vestibular impairments alone can put one at a great risk for falling. Diabetes is also an independent risk factor for falling. That perfect storm analogy, both vestibular loss and diabetes together, puts one at a great risk for falling. It's a very dangerous combination, and the likelihood of someone with diabetes also having a vestibular impairment is greater than in the general population. We have very strong associations observed in large population-based studies, and though the clinical study shows some mixed findings, it's probably because the vestibular system is complicated. It's not just one thing, it's multiple sensory organs, and there are a few things we can do. We can use screeners that are short and simple and that identify someone who may need a further evaluation. These can be self-report, like a single question, ("Have you fallen?"), or short questionnaire screenings can be functional, like a static balance task with your eyes closed or maybe Timed Up and Go. It doesn't require any additional equipment except a chair. And then counseling. We can't mitigate a falls risk, if you're unaware of [if] the risk is present. So, managing blood sugar lowers the risk of the vestibular pathology. It lowers the risk of BPPV, and if someone is already at risk and you perform a screening, [and] it seems they're at a falls risk, there are interventions that can help. And that's a lot of what Dr. Ballard, our next speaker, is going to talk about in a bit more detail.

Slide 75: **References and Resources**

And this is just a list of references and resources and all the websites that included information on the screeners that I talked about. So, thank you for the opportunity to present. So now, I'm going to turn things over to our last panelist, Dr. Ballard.

Slide 76: Vestibular Therapy

Anjulyn Ballard: Thank you Dr. Piker. Good afternoon, everyone. Today, I'm going to be speaking to you about vestibular therapy.

Slide 77: Vestibular Therapy

Okay, so vestibular therapy is a type of physical therapy used to adapt or strengthen other senses in order to treat balance related disorders. Some of the common problems that result from vestibular disorders are dizziness and balance, vertigo, and visual disturbance.

Slide 78: Prescription and Administration of Activities

As we've learned today, damage to the inner ear is the cause of these symptoms. In order to alleviate the symptoms, the brain has to learn to use other senses, such as vision or balance from the lower limbs in order to compensate. Prescription and administration of vestibular therapy should be facilitated by an occupational or physical therapist. They are trained to adequately identify problems related to an individual's vestibular disorder. A therapist exam will confirm where the symptoms of dizziness or imbalance, for example, are coming from, and they can prescribe exercises that directly target the identified symptoms.

Slide 79: Prescribed Exercise Methods

Here are some prescribed exercise methods that therapists use. Now, please be aware that the following information is being shared for educational purposes only and should not be used to diagnose symptoms or prescribe exercises. Again, diagnosis and prescription should be completed by a trained therapist. Depending on the vestibular-related problems, three principal methods of exercise are generally used, that being habituation, gaze stabilization, and/or balance training. The images that you see here are basic examples of the exercise categories. Several types of exercises exist for each category with some being more advanced than others.

However, a trained therapist can prescribe the best exercises for an individual based on the severity of their symptoms and what someone can tolerate, because again, safety is priority. Habituation: habituation is used to reduce dizziness through repeated exposure to visual stimulation. So, of course, if someone comes to a therapist and describes that they have symptoms of dizziness, then more than likely they would use habituation exercises to treat that symptom. Gaze stabilization is used to improve control of eye movement to make vision clear during head movement. So, if someone came and said that they—that things appeared to bounce or jump around with head movement–then a therapist would be likely to use gaze stabilization exercises to treat those symptoms, and then we have balance training. Balance training is used to improve steadiness, so that daily activities such as self-care or leisure activity can be performed successfully, and some symptoms of balance disorders or balance symptoms would be difficulty walking on uneven surfaces or difficulty walking in the dark.

Slide 80: Tai Chi

So, aside from the general prescribed exercise methods that we just looked at, I want to talk a little bit about Tai Chi. Tai Chi is an exercise that is generally used for a variety of health benefits, including balance. Tai Chi is also recommended by trained therapists. It primarily aids in increasing balance, because it increases sensory that comes from the feet and lower limbs. However, if someone's imbalance is caused by dizziness or unstable vision, Tai Chi may not completely alleviate these symptoms, because it doesn't target visual stimulation or control of eye movement. Again, it primarily increases sensory that comes from the feet or lower limbs, however, it is best to consult with a therapist or medical professional before starting any exercise regimen. And, of course, if insurance or cost are a concern, sometimes therapists provide free or community service. So, this may be an option for individuals who may not be able to afford therapeutic services.

Slide 81: A Few Things to Remember

So, just a few things to remember. Vestibular therapy is used to treat symptoms that result from inner ear damage. It's best to seek therapy from either professional [occupational or physical therapists], because they are trying to identify the symptoms and prescribe specific therapeutic services. Tai Chi is an exercise activity that's generally used to restore balance; however, it does not directly treat dizziness, vertigo, and visual disturbance, but it may alleviate these symptoms in some capacity. Thank you all so much for your time today, and I will now turn the presentation back over to our moderator, Dr. Kathy Dowd.

Slide 82: In Summary

Dowd: Thank you so much, Dr. Ballard, and thank you to all our speakers for the presentations you made today. In summary, we have discussed today the impacts of diabetes on the ear that are often not addressed; refer to an audiologist for problems with hearing imbalance; prevention is key, because hearing and vestibular loss are permanent; manage the ABCs of diabetes; early identification of hearing and balance problems; audiologists can help manage hearing loss by fitting–by evaluation and fitting of hearing aids; vestibular impairment and diabetes both create an increased risk of falls; screenings for vestibular impairment are short and simple and can help identify someone who may need further evaluation; vestibular therapy by trained professionals is used to treat symptoms from inner ear damage; and Tai Chi is an example of an activity that is generally used to help restore balance.

Slide 83: Use the Chat Box

Now, before we start taking questions, we'd like to hear from you. What resources, handouts, webinars would be helpful for you to feel more comfortable with talking about this topic? Please type

your answers into the chat box. And thanks for sharing your ideas. We'll review them for our future planning.

Slide 84: Take Charge of Your Diabetes: Healthy Ears

One resource we can share now is a new handout for people with diabetes. It's available on the CDC website and is part of a series on preventing complications. Written for people with diabetes, this fact sheet describes how balance can harm the ears, when to see an audiologist, the signs of hearing loss and balance problems, and tips to keep the ears healthy. This fact sheet and the entire series are available on the CDC website in English and Spanish. Thank you to all of our presenters for this excellent session on diabetes and ear health.

Slide 85: Question and Answer

Now, we invite all of our presenters back to answer your questions. As a reminder, you can submit questions via the Q&A box below. So, the first question in the box is, “I may have missed it, but what is the preventability of hearing loss in patients with diabetes?” And Chris, Dr. Spankovich, you'd like to answer that question.

Spankovich: Sure, no problem. So, if you recall, as we were chatting about what causes hearing loss, the three most common factors are going to be noise exposure, ototoxic medications, and number three is age-related effects. So, we'll start with noise. Noise is 100% preventable. So, an individual utilizing hearing protection devices when they're going to be around loud sounds, if they work in a loud environment, definitely utilizing ear protection devices: they're going to be a lot of power tools, lawn equipment, protecting their ears, turning down the volume on music, not listening too loud or for extended durations of time are things that can prevent that as a component contributing to the hearing loss that a person acquires, because persons with diabetes are at increased risk for noise-induced hearing loss. Number two is ototoxic drugs. So,

certain medications can be ototoxic. So, if those can be avoided, which is not always the case, but if they can, that can help prevent damage, but also just monitoring an individual that is on an ototoxic drugs, so we can identify early indices of pathology [that] can be helpful as well to make informed decisions on the benefit versus cost of using that type of medication. And finally, age: age is really referring to your overall health, and so a person that eats healthy, that exercises, these things can help contribute to reducing some risk and odds of hearing loss. They're not going to prevent hearing loss completely, because a big factor that causes hearing loss is your noise exposure, but there are things that can help mitigate some of that risk.

Dowd: Thank you so much, Dr. Spankovich. The next question is, “Please advise on recommendations for types of protective coverings for use in the workplace during travel, takeoff and landing, routine environmental background, community, and residential noises.” And Dr. Spankovich, I see you would like to answer that question.

Spankovich: I don't have to, but I will. I'm sure one of our other speakers is more than able to do so, but, you know, the type of hearing protection devices we recommend are really dependent on specific scenarios. So, you can utilize foam earplugs, you can utilize supra-aural devices that go over the ears. One thing to look at is the noise reduction rating, the level of sound exposure that you're going to be in, the duration of exposure. Not everyone needs maximal attenuation or protection in every environment. So, for example, a person that enjoys going to concerts—they don't need to wear foam yellow earplugs or the big headphones over their ears. They can look into devices called musician ear plugs, and these ear plugs provide a slightly lower amount of noise reduction and a flatter attenuation, so a person can still appreciate music but be protected. For an airplane, they have these things called “EarPlanes,” and that's really for mitigating some of the pressure issues as you're flying, but, you know, it really comes down to

some of the specific scenarios. Look at the noise reduction rating and find a good quality product and one that you find comfortable and will use consistently.

Dowd: Definitely. Thank you. The next question, “Is there any correlation with insulin resistance and hearing loss?” Who would like to answer that?

Spankovich: I'm happy to. So yes, I mean—you know—type 2 diabetes, you know, at its base has some level of insulin resistance obviously involved, and so insulin, interestingly, does not have a primary role within the cochlea in terms of glucose regulation. It's more involved in protein synthesis, signaling pathways, but indeed, if that's compromised, that can lead to some of the issues with microangiopathy as well as development of diabetes in an individual now being [in] a place where they have these other cellular issues such as mitochondrial dysfunction [and] reduced glutathione. And it's the combination of all those factors that are now going to increase their risk for hearing loss and balance issues as well.

Dowd: Thank you, Dr. Spankovich. “If a patient is prediabetic [has prediabetes], is the risk of hearing loss the same as someone who has active diabetes, and what can they do to avoid future problems?”

Piker: Well, I don't work with hearing loss; I work with vestibular loss. But there has been a little bit of work looking at the difference between prediabetes and diabetes with the vestibular system. I imagine we'll see similar things with the auditory system, but those who are prediabetic [people with prediabetes] are at lower risk. There's one particular study where they looked at kind of vestibular wave form. It wasn’t the best metric to look at, but they looked at the size of it, and those who were prediabetic [who had prediabetes] looked more similar to normal controls, and those with diabetes had a different looking response. And that was really a study that emphasized the longer duration of the disease, and the more severe it was, the greater the risk,

at least for the vestibular system, and I imagine it's going to be similar for the hearing loss as well. And so, to avoid future problems, they really are avoidable. If you can control blood sugar as best as you can, a lot of that damage that can occur in the inner ear can be mitigated quite a bit. And with something like BPPV, those little calcium crystals break loose, but we can stop that membrane that's deteriorating, that's breaking them loose, if glucose levels are better controlled and blood sugar is better controlled.

Dowd: Thanks so much, Dr. Piker, and the next question is, “As a CDCES or a diabetes educator, supporting the diabetes self-management education program to deliver services via telehealth, I have discovered that telehealth can improve the patient experience for those who lip read. I am interested if our presenters–on our presenters' thoughts on this.” And, Dr. Gaffney, you'd like to answer this, I see.

Gaffney: Yeah. So, when we look at overall communication, even if you have normal hearing, you utilize facial information to help supplement any auditory information. So, if you have hearing loss, you're going to rely on those facial cues more, and it's not usually just the lip reading; it's also overall facial characteristics [and] facial movements that help to fill in some information. You can tell somebody's tone, somebody's—you know—what they're trying to say, even if you're not actually reading the lips. So yeah, face to face is always the best communication, because you have visual and auditory.

Dowd: Thank you. Yes, that's important. It does add about 30 to 40% just to be able to lip read someone that you're talking with. The next question, “Also interested in treatments for BPPV and exercises.” So, Dr. Gaffney.

Dowd: Yeah, so either Dr. Piker or I could answer, but I just grabbed it. So, for BPPV, that is, most audiologists who do vestibular and physical therapists love it, because it is treatable. So, you're

doing a maneuver to move those otoconia or those little crystals back to the utricle. So, there are a number of different maneuvers that you can do. It's primarily based off of which canal the otoconia is in. Most often, the otoconia goes into the posterior canal, the one at the bottom just because of gravity, and so you may have heard of the Epley [maneuver]; that's probably the one that's most well-known. But there's also the Semont [maneuver], and there's a few other ones out there, but the Semont and the Epley are the most commonly used, and it's just placing the head in certain positions to get that otoconia back to the utricle.

Dowd: Thank you, Dr. Gaffney. Yes, it's very treatable. The next question, “I have come across patients with diabetes where they are not covered for hearing aids or their hearing aids do not work well for them. Do you have any advice in these situations?”

Gaffney: Yeah, so the hearing aid coverage is going to depend on the insurance company itself. Medicaid and some third-party insurances like Blue Cross Blue Shield can cover either a portion or all of it. Medicare does not cover hearing aids. So, patients either have to use a supplemental insurance or pay out of pocket for those devices. As far as them not working well for the patient, it could be a number of things. First would be that it's programmed and verified appropriately for their hearing loss. The other thing is that, due to the nature and the plasticity of the brain, you really need to use hearing aids consistently—so all day, every day—to get the most benefit out of it. And so, one place that we see patients struggle is if they're trying to use them situationally, because the brain doesn't have enough time to adapt to that amplification and to getting that sound back to that auditory cortex. So, the other thing, you know, [that] we talk to patients about is using them consistently and not just in situations, generally, that they find difficult, which is usually things like really noisy environments, like going out to dinner or things like that, where it's harder to hear.

Dowd: Thank you, Dr. Gaffney. “So, hearing loss in diabetes, is it caused by damage of the nerves?” And I see you're stepping up, Dr. Spankovich.

Spankovich: Yeah, sure. So, as we described when we were going over the pathophysiological consequences of diabetes, where we observe primary changes are going to be the outer hair cells. And so that's not a neural element. Well, it's a type of cell, but it's not the nerve itself, okay. And so those sensory receptors, [those] outer hair cells are susceptible to damage. The other portion of the pathway that's going to have primary damage is going to be at the synapse. So, that's going to be the connection between the inner hair cell and the auditory nerve, and then over time, what we begin to observe is then degradation of the nerve itself. And so, it's going to be the hair cells, the sensory portion, the synapse, and then the nerve itself, and that's why we call it sensorineural hearing loss.

Dowd: Thank you, Dr. Spankovich. “What are your thoughts regarding masks inhibiting hearing? Any ways you can think to improve communication with these barriers?” And definitely in this time of COVID [coronavirus disease 2019]—and we don't know how long this is going to last, it (having a clear mask) is a definite advantage. Does someone want to address this?

Spankovich: I think any of us probably can. It's in a slide in my part of the presentation. If you look at the table that talks about communication strategies (slide 56), those communication strategies in that table are actually from our article that we wrote on COVID-19 and hearing loss and actually dealing with masks. So, it really depends on the mask. Different masks will affect the ability to hear speech in different ways. The N95—like a real deal N95 like this one—that's going to have the greatest amount of attenuation of higher frequencies down [to] about 12 dB, which can give you like a slight degree of hearing loss, or if you already have hearing loss, more of a hearing loss, and then the more of a cloth mask is going to only have a few dB, but it also takes away

visual cues. So, you can't see the person's mouth when they're speaking. So, having this person speak more clearly, not being afraid to ask them to adjust or rephrase, and then reducing background noise can all be very beneficial things. But you'll see a list of some of those communication strategies on one of my slides, which will be available in the future.

Dowd: Thank you, Dr. Spankovich. Now here's more of a statement from one of our attendees: “I'd like to kindly mention at this point that I recently published a study that showed for the first time that the increasing trend in hearing loss prevalence is not related to aging of the population, as widely believed, but potentially to social and lifestyle changes. These lifestyle changes might be reflected in the increased prevalence of diabetes in the population in England.” So, thank you very much for that note. Yes, I think our lifestyles have changed quite a bit over the last 20 years, contributing to this problem in diabetes.

Spankovich: And that's why we call it age-related effects, because it's not just the age. That is a factor. I mean, there's wear and tear that happens over time, but it's your lifetime of noise exposure, it's your lifetime of medications, and it's your lifetime of your health that really contribute to the hearing loss that we acquire as we age.

Slide 86: Thank You

Dowd: Definitely, definitely. So, thank you to everyone in the audience for some great questions. If you have additional questions, please send them to the email address on your screen. We will follow up with you after our webinar. Be sure you get your continuing education credit. Instructions will be emailed to you. As a reminder, a recording of this webinar and the slides will be shared in the near future. This concludes our webinar. Thank you for participating.