

## **Research Symposium Transcript HLAA Convention 2011**

>> Brenda: Good morning.

I want to welcome everybody to this year's research symposium.

We started these several years ago because we know that there's a tremendous amount of excellent research going on that relates to things that will eventually impact our lives and we rarely get an opportunity to hear about it from the people that are working in the field. So, this is an opportunity for them to share with you what is going on.

We have a really excellent panel lined up for you this morning talking about issues around noise and noise-induced hearing loss which is a very, very important topic today given the kind of noise that we're surrounded by, particularly for young people and with all the new devices that are coming along and in the workplace as well.

So, I'm going to just turn it over now to Dr. Clark who is going to be moderating the panel and he will introduce the panel himself.

Thank you very much.

Dr. Clark.

Thank you.

[ Applause ]

Dr. William Clark>> First of all I'd like to welcome everybody to this symposium, I hope that we have an interesting and productive morning.

My job as moderator is to introduce the participants, and the most important participant who is listed on the title slide is Dr. George A. Gates. George is medical director of the Deafness Research Foundation and until yesterday Dr. Gates was going to kick off this symposium, participate in it and moderate it and direct the discussion. Unfortunately what's turned out to be a relatively minor family emergency has prevented Dr. Gates from attending today. He sends his regrets that he's not able to be here. I will introduce him for you, though, so that you know his credentials. George is the medical director as I said, of the Deafness Research Foundation. But he's also the Emeritus Professor of otolaryngology head and neck surgery and Director Emeritus of the Virginia Merrill Bloedel hearing research center at the University of Washington School of Medicine in Seattle. So we're very sorry that George is not able to join us today and we, who are his students and friends and colleagues are committed to presenting a quality symposium in his absence.

I am Bill Clark, I'll introduce myself.

I'm the director of the program and audiology and communication sciences at Washington University School of Medicine. I'm also a professor in the department in the otolaryngology and department of education. The communications science trains master students in deaf education, that is as teachers of the deaf we emphasize listening and spoken language skills, we're very closely affiliated with and

actually the Central Institute for the Deaf is part of our program.

We also have a clinical doctoral degree in audiology and Ph.D. degree in speech and hearing sciences. So that's kind of my background as a scientist, researcher and administrator.

The first speaker this morning is Sharon Kujawa, Sharon is here to my right. Sharon is associate professor of otology and laryngology at Harvard Medical School and director of the department of audiology at the Massachusetts Eye and Ear Infirmary.

The third speaker today is William Murphy, Ph.D. Bill is a captain in the United States Public Health Service and he is affiliated with the national institute for occupational safety and health. His expertise is really in acoustics and hearing protection and occupational noise-induced hearing loss.

We'll start this symposium in George's absence with just a brief quote from Robert Louis Stevenson, 1850-1894, *A Child's Garden of Verses*. *Dusty and dim are the eyes of the Miller, deaf are his ears with the Moil of the mill.* That's from *A Child's Garden of Verses*.

We've been aware of the fact that excessive exposure to noise can cause hearing loss for a couple of hundred years. Didn't begin just with the industrial revolution in the 1850s but prior to that, boilermakers whose trade was to make -- to pound out with hammers the insides of boilers, were known even in the early 1800s to have hearing loss in the communities where there was a lot of boiler making, there was a lot of hearing loss -that's how come it was originally called "boilermakers' deafness."

People don't just lose their hearing from the workplace, but from participating in noisy leisure activities, they lose their hearing certainly from genetic causes, incidents associated with birth and exposure to noise throughout their lifetime including exposure to guns - shooting and target shooting, also from listening to things like iPods for a long period of time.

We're going to have three presentations today and the first presentation, I don't actually have the title, but Dr. Kujawa will talk about neurodegeneration in ears after exposure to noise.

Dr. Kujawa.

>> Good morning, everybody.

The first thing I'd like to do before I get started is to thank the Deafness Research Foundation for Dr. George Gates in particular for his invitation to speak to this group today.

The DRF gave me my very first grant so I have a warm fuzzy place in my heart for them. They get many young investigators started on their research careers and they're to be commended for that kind of activity. When Dr. Gates invited me to speak at this symposium, he asked if I would talk about what noise does to ears and hearing.

Many of you in the audience may not actively be engaged in hazardous activities in relation to noise, but I would submit to you that many of your friends and family members are and so this information is good to disseminate to them as well even if it doesn't relate directly to your own experience.

So, my role today will be to talk about noise, about what it does to the structures in our ears and what it does to our hearing. I'm going to talk first just a little bit to get us all on the same page about how the normal ear looks and functions in health and in youth.

And then talk about some of the immediate consequences of noise exposure.

I'd also like to share with you some of the more recent research that we're doing in my laboratory that is very sobering and that suggests that noise has long-term and progressive consequences long after the exposure to the noise has stopped.

And so perhaps a more appropriate title for my talk today would be, *noise is more dangerous than we thought*.

So going forward then to look at the normal structure and function of the ear, this is a system that the people on this stage get very excited about. We find that it is an exquisitely organized and structured system and its whole job really is to optimize response to sound. When you think about the range of sounds in the environment some of them are very faint, some of them are very loud and that system has to be able to respond under all of those conditions with good fidelity. We have an ear that you can see portions of here, so -- I guess -- I can't make that pointer work.

The outer part of the ear which is easy for you see of course, you have a Pina, a place that collects the sound, it shapes it in certain ways and funnels it down the ear canal towards your ear drum. And then a portion of the ear that you cannot see but where I'm going to be spending most of my time this morning is the cochlea of the inner ear. So this is where the hair cells that you have probably all heard about, live; this is where the output from those hair cells goes on to send signals to the brain.

If we look at the structure of the inner ear and cochlea of the inner ear you're going to see some structures that I'll be talking about today. So the hair cells live in an area called the organ of Corti and maybe Dr. Clark can point that out for me, thank you.

And then the nerve fibers leave that organ of Corti and they have their cell bodies in a place called the spiral ganglion and then the fibers go on and ultimately send the information to the brain.

So, what I'd like to do is just start with this little animation for the annoying mosquito that basically the sound created by that sound source causes waves of disturbance that reach the ear as sound. Again, we have that sound entering the ear through the canal and finding its way here through the air-filled middle ear space, which allows a way to match the air-filled environment of the middle ear in to the fluid-filled environment of the inner ear. Those fluids are set in to motion by these pressure waves. You can see the ear drum in the middle ear bones moving and causing that disturbance in the fluids of the inner ear.

At threshold or at the softest sound that can be heard in a normal hearing ear, those motions are exceedingly small. And so there is a subset of hair cells whose job it is to amplify those motions and to try and optimize the signal that is seen by the inner hair cells. It's the inner hair cells, that single row of blue hair cells there, that are the ones that are primarily connected to the brain. And so those cells act as the traditional sensory receptors in the inner ear. So those signals go to the brain first through the auditory nerve.

Now again, as I started to say, this structure is exceedingly exquisite in its architecture, what you see on the left is the organ of Corti that I talked about. You'll be able to see later the hair cells that are

contained in that organ of Corti but on the right, basically you have a bird's eye view of the top of that epithelium, you see what corresponds to the three rows of outer hair cells on the left, and the single row of inner hair cells which then send their signals through the auditory nerve to the brain. On the right side.

Again, the normal ear is sensitive to exceedingly small motions, these pressure waves that are set up in the environment that ultimately reach the structures and fluids of the inner ear in some cases are very, very small. But loud sound produces very large motions. And so what we're going to be talking about this morning is basically what those large displacements, those large motions do to the ears in hearing.

The first thing that they do is they cause hearing loss. And when we look at what happens after a noise exposure we often see something that looks like this. Now, in this graph on this Axis on the left you have threshold shift. Now, threshold is the softest sound that any of us can hear in this room. Your threshold might be a little different from my threshold but for each of us it's the softest sound that we can hear. When your ear is exposed to a loud noise, that threshold level changes. It takes more sound for you to just barely hear the sound and so we call that a threshold shift.

Large threshold shifts are at the top of the graph, smaller numbers are going down. So in the minutes and hours after a noise exposure, you see that the threshold shifts are maximum. Right after the noise you have this big change in sensitivity, but with time after the exposure threshold sensitivity begins to recover and it recovers fairly quickly, of course how much it shifted in the beginning and how fast it recovers and how completely it recovers depends on characteristics of the exposure, for example, how loud it was, how long you were exposed to it.

We also know that it depends a bit on characteristics of the individual. All of us have different genetic makeup and we certainly know that our genetics influences our susceptibility to any number of problems, one of them is noise-induced hearing loss.

So, for some conditions of exposure hearing recovers but it doesn't come all the way back to where it was before the exposure. And in that case we call this a permanent threshold shift, or a permanent hearing loss.

And if you look on this graph, this one will be a little more familiar to most of you. You see an audiogram, that is the standard way that we characterize hearing sensitivity in the clinic, on the left of the graph again is the level of the sound, how loud it had to be before you were just able to hear it. And the different frequencies or pitches of the tone go from left to right. And in this ear (there are two ears here plotted), you see that in the low pitches on the left side of the graph the hearing is very near the top. And so that's quite normal hearing sensitivity. But as you move to the right of the graph and start looking at sensitivity for higher pitch sounds there is some hearing loss. And that shaded area is a general guide of what we typically refer to as a normal range of hearing.

So in this case the hearing is falling outside of that normal range in the high pitches. Now, with time after exposure, some of that threshold elevation may recover, so you saw that on the previous graph. On an audiogram it might look something like that, less threshold shift in this ear perhaps three days after exposure than there was three hours after exposure.

So, what else happens to an ear after it's exposed to loud noise?

I've suggested that the pressure waves that are associated with a loud sound can actually cause mechanical damage to structures in the delicate structures of the inner ear. And on the right is the figure that you saw in a previous slide and on the left you can have a better notion of what the hair cells look like that are sitting in that organ of Corti. And in this case we see normal outer hair cells on the left. We see a single normal inner hair cell on the right.

Those of you that are pure of heart might even be able to see the stereocilia, the little hairs that extend above the top of the hair cell for the inner hair cell on the right.

But fairly quickly after a noise exposure you can see that the hair cells are first pretty unhappy, but in this slide are missing altogether in the case of the outer hair cells.

So, this image was taken two days after a noise exposure in an ear that had a permanent threshold shift after noise. And you see that the outer hair cells on the left are missing completely, the inner hair cell is still there. I think I can see it there.

Even when hair cells survive that kind of an exposure you can get changes to the delicate structures at the tops of the hair cells. We call those little hairs, stereocilia.

On the left you can see what they look like in the normal case, you have the tops of the hair cells where you can see the three rows of stereocilia from the outer hair cells.

And the single row of inner hair cell stereocilia, they're beautifully organized.

They're actually connected to each other with fine little filaments so that when sound comes in and they bend, it allows currents to flow through the hair cells and that's how we get the release of the neurotransmitter substances that are basically the appropriate signal for our nerve, that's how we communicate with the nerve.

But on the right you see some floppy stereocilia or stereocilia that are missing altogether. And those stereocilia are not going to be able to respond to the pressure waves that are being transmitted through the hair cell system. If we wait a longer time after noise exposure, in ears that have lost hair cells, what we often see is that the nerve fibers that are communicating with those hair cells begin to die as well. So, you have a hair cell, you have a nerve fiber leaving the hair cell going to that area that I told you was the spiral ganglion which contains the nuclei, the cell bodies of those nerve cells. And in the top you can see on the right there's this area of cell bodies, it's pretty well packed in there. There are lots of cells that are in a normal ear. You can see that all the hair cells are there in that particular micrograph.

But if we wait after inner hair cells die we see that we start losing the nerve fibers that communicate with those hair cells. And if we wait a long time that spiral ganglion area becomes quite depopulated. There are few cells left in that spiral ganglion when they're corresponding inner hair cells are gone.

So to this point I've been talking to you about what happens in ears that have a permanent hearing loss after noise. What I'd like to do is talk to you next about ears that appear to recover from a noise exposure.

Because I'm sure you all know that not every exposure you get causes an immediate and permanent hearing loss. So, this graph basically shows us that for certain exposures that don't exceed about 40 or 50 db you actually have shifts in sensitivity that recover with post-exposure time and they pretty much

recover to baseline. So you end up with threshold sensitivity, the softest sounds that ear can hear that are not different from ears that were never exposed to noise.

Looking again at the audiogram example, you have hearing that is improving with time after exposure, ultimately recovering to completely within a normal range of values for that ear. What does that mean for hearing in that ear and what does that mean in terms of what's been going on underneath? The things that we can't see?

We know hearing came back to normal and that gives us a pretty warm and fuzzy feeling that everything is okay, and in fact if you come in to the clinic after a noise exposure and you come in and we test your hearing and it looks like that, you're likely to hear "you're fine," you dodged that bullet, everything looks really good and your ears have recovered after noise.

We looked at that specifically in my laboratory in a model where we can completely control the noise exposure that we deliver and we can look at specific post-exposure times. We can look at the sensitivity of those ears to tones and then we can go in and we can look at the ears themselves and see what injury might be underlying some of the threshold shifts that we see at different times.

So the first thing you see in this graph in the red circles is what happened to hearing one day after a noise exposure. And you see the thresholds are elevated so again we're shifting back to this -- it's like hearing loss but it's displayed in a reverse way on the graph. Threshold shift - the bigger the threshold shift what that means is the poorer the hearing. So one day after exposure we use tests of sensitivity that frankly we use in the clinic every day. We use otoacoustic emissions on the left, which give us a functional image of what the outer hair cell system is doing, those little mechanically active hair cells. And then we use auditory brainstem response, which is something that allows us to look at the neural sensitivity of the ear. And we see that one day after the exposure you have a big threshold shift. By both of those metrics.

But in the days after that exposure sensitivity begins to recover and by two weeks and eight weeks after exposure, you're all the way down to baseline, these ears would be considered completely recovered from their noise exposure as far as threshold sensitivity is concerned. The direction of the threshold shift after noise.

When we look at responses, though, at different levels, so I've been concentrating on very low level signals. The ones that you hear right at threshold. But we don't listen at threshold, we listen to sounds that are above our threshold. And when we look at responses that grow as we make the stimulus louder and louder, we see on the left that those hair cell-based responses come completely back to normal by eight weeks after the exposure.

Again, the red circles are what the responses looked like one day after the exposure and the black circles are what they look like eight weeks after exposure. And they're not different from an ear that has not been exposed to noise. Which is the green.

On the right, though, when we look at the response of the nerve we see again the response is compromised one day after but it never comes fully back. We have -- you have to notice that the Y-axis

on this graph is a log scale so that drop in the size of the response is a response that's half as big as it is in a normal ear, in a ear that has not been exposed to noise. So, we decided to look at those ears and try and figure out why those responses persisted on being abnormal compared to unexposed ears.

When you look in an ear a short time after an exposure, you can see at the base of the inner hair cell, which I have circled there, this kind of “bleeding” - the cell has areas that become very swollen and leaky, and that's very evident in these micrographs.

That happens within hours of a noise exposure. And it happens because the chemical substance that the inner hair cells use to communicate with the nerve have been swamped basically with a loud sound, you get more of the neurotransmitter, you can't get it out of the synapse as fast as you need to get it out. It sits around there and it actually behaves like a toxin. And that toxin damages that nerve terminal because it's not cleared from the synapse in a fashion that it should be.

So, we are very fortunate these days because we have methods, very sensitive methods that we can go in and look at different structures in the inner ear.

And we're aided in this effort by substances called antibodies that we can stain tissues with and they will cause different proteins to light up so that we can see them. That previous slide that you saw, you probably trusted me when I said that it was all swollen at the base of that inner hair cell, but that's hard to quantify. That's really hard to see what's going on.

And there's a lot of variability in what that looks like and in fact, after about a day after exposure, those little swellings go away and so, what are you left with - it's hard to tell what went on. But we can go in, we can stain those tissues and we can look at what happens at different times after exposure. We have a compound that stains the structures that hold the neurotransmitter substance. They stain red, you can see those little red dots there. And with them stained like that, we can go in and count them.

And we can say, okay, in an ear that hasn't been exposed to noise we have this many dots per hair cell. And in an ear that has been exposed to noise we have this many dots. And that's precisely what we do.

We also have stains that will allow us to see the nerve fibers. So this is exactly the same section of tissue in the first slide, I only let you see what we call the synaptic ribbons which are the structures, the little red dots that hold the transmitter.

Here I've turned on the green channel and I can now see the nerve fibers in that same tissue sample. So, let's just look at an example here.

Here we have an unexposed ear, we have a row of inner hair cells and you can tell that they're there because the big red dots are the nuclei of each of those hair cells.

So first of all, we can tell all the hair cells are there. I've drawn a little white line around one of them so you can kind of get an idea of the orientation of those inner hair cells in this particular slide. And then below the nucleus you can see all the tiny red dots.

And each of those dots is a is in natural particular -- synaptic ribbon that communicates with one nerve fiber so one dot, one fiber, one ganglion cell in the spiral ganglion.

Three days after a noise exposure in which the thresholds came completely back to normal, so these are ears now with temporary threshold shifts. Temporary hearing loss.

Thresholds came back, we're looking at the ear three days later and I think all of you can see, even without counting that there are fewer red dots in the bottom panel than there are in the top panel.

They're also different looking, they're in the wrong place, some of them are fat, they look like they're kind of blobbed together. There's many different changes happening in this ear that are evident a couple days after noise.

In an ear that just based on its audiogram we would have said, it's normal, it recovered.

Okay?

When we go in and we count these red dots, we see -- so the green circles are the number of dots at different places in the cochlea. In an ear that hasn't been exposed to noise. And you can see that one day after noise we've lost about half of those ribbons.

We lose them mostly in the region where the threshold shift from the noise was biggest right after the exposure. So, we had a certain amount of hearing loss in those high pitches after the noise. We look at that same place in the cochlea one day after noise and we've lost half of the ribbons. So, if the ribbon isn't there, nobody's talking to that nerve fiber any more. There's no way for that inner hair cell, at least that one ribbon to communicate with its nerve fiber. That is a permanent change, that never gets any better.

For as long as we have looked in ears after noise, those ribbons don't come back.

When we look at the nerve fibers, again, you can see on the left in an ear that hasn't been exposed to noise, that kind of green rat's nest at the bottom there, those are all the nerve fibers, those are pretty hard to quantify. But just in a qualitative way look at the panel on the right and I think everybody here would also agree that there's less green stuff down there, okay?

So there are fewer fibers in that same ear three days after the noise exposure the when we go back now and look at those ears at a long time after the noise exposure, so again in the top you can see a section through the ear. You can see the hair cells on the right side, you can see the spiral ganglion which is that really densely stained area on the left side of that photo micrograph. When we look at ears that have been noise exposed a long time after noise we see that they have lost a lot of their nerve cells bodies. So what we see acutely after noise within 24 hours is what we end up seeing in the nerve as many as two years later. So, we think we know a little bit about which nerve fibers die, because not all of them die. About half of them die, at least for the really broad range of exposures that we've tested to this point. And we think they are fibers that respond with low spontaneous rates.

Nerve fibers have all kinds of different response properties and that's a good thing it extends our dynamic range of hearing, some fibers have really low thresholds they can respond to very, very small signals. Some of them have higher thresholds but they extend their response to much higher levels on the other end.

We think we're losing a subset of these fibers, what I'd like to talk about next is what we think the consequence of losing those fibers is. So just to summarize, we have a noise-induced insult in an ear, the hearing recovers, you get this swelling of the terminal, is that you can see at a short time after exposure, the dendrites, the terminals of those nerve fibers that contact the hair cells pull back away from the hair cells.

When that happens, those two elements can't communicate with each other any more.

With a longer delay, the nerve fiber continues to die back and ultimately with a very, very long delay compared to the other events that we're looking at, you lose the cell body of the nerve itself.

So do we care if thresholds come back? Everybody in this room knows that when you come in to a medical facility, you come to the hearing clinic, and you get your hearing characterized, we use a test that looks at your threshold for sounds. And the same thing happens when somebody is exposed to noise. The primary thing that we do after noise is to look at their thresholds for tones. It is the standard way, the tests are very well standardized we know a lot about what it means, it's kind of the main thing that audiologists do when they're trying to characterize what happened to an ear after noise.

The other important point is, everything that we do to establish how risky it is to be exposed to a certain level of sound is based on those threshold kinds of tests.

So over long periods of time people have studied how risky it is to be exposed to certain levels of sound. And the guidelines that we use to determine what we allow people to be exposed to are based on threshold sensitivity. But what I've just told you is not all ears and up with a threshold elevation after noise. And when that happens we generally think no threshold shift, no risk. The hearing has come back so exposure was safe. I obviously don't believe that. And so something else happening in noise.

When you have normal hearing or not it's more difficult to understand certain signals in a background of noise. So, if there's lots of people talking, if there's music in the background and you're trying to hear me but she's making more noise than I am, it's going to be difficult to sort out speech from noise. And if you look at this image here, you can kind of see why that is the case. The spectral information in a speech signal gets embedded in the spectral information in the noise and it's pretty hard to separate those back out.

One thing we do know is that those low spontaneous rate fibers, the ones I said we think are the ones that are preferentially targeted by the noise, are thought to be particularly important in helping us ferret out that speech in noise kind of information.

So their loss would be even more troublesome to an ear that had been exposed to noise or ends up with a hearing loss after noise.

We also know tinnitus is a very common consequence of noise exposure and we know that loss of peripheral nerve fibers after noise or after other kinds of insults can lead to changes in central auditory structures that reflect those changes in the periphery.

These peripheral changes, the degeneration and the central reorganization that can happen as a result of that can lead to a number of perceptual abnormalities and one of those is tinnitus. There's a great deal of research going on throughout the country now trying to sort out what kinds of central changes happen after noise, what structures are involved and what triggers those events. But basically, you have a situation where you end up hearing Phantom sounds or in fact sounds can become uncomfortably loud to you that perhaps are not too loud to somebody else. We know that noise is a very common cause of tinnitus.

The American Tinnitus Association gives us these statistics which I think are pretty sobering in samples of workers that are noise exposed on the job, versus those that are not noise exposed on the job. You look at some pretty dramatic differences in the numbers of those folks that report having tinnitus. So, let me just summarize what I've said here this morning.

We certainly see permanent hearing loss after noise, that's probably the most common thing that happens, people are exposed to noise over and over in their lifetimes and gradually they accrue changes in their threshold sensitivity. Often those changes are related to loss of hair cells. But even in ears that completely recover their threshold sensitivity, we see changes that those thresholds mask. So we all think that the ear has recovered after noise when thresholds recover. But yet we see the synapses the communication points between hair cells -- sorry -- between hair cells and nerves are interrupted, even when the hair cells themselves are not lost after the noise exposure.

We know from this work that this neural degeneration doesn't have to change threshold sensitivity, but we do get some clues in the responses that we record in these ears and higher level responses stay permanently reduced in these ears. We believe that this kind of degeneration can contribute to a number of perceptual problems in these ears, we think that it may contribute to difficulties hearing speech and noise, for example, or in perceptual abnormalities like tinnitus or hyperacusis. And we also have learned that the kinds of criteria that we use to determine what we allow people to be exposed to on the job, assume that recovery of thresholds means that the noise didn't have a lasting damaging affect on the ear. And since that's not true, we think that noise is more dangerous than we all tend to think that it is.

I'd like to just take a minute and thank my collaborators and my funding source for this work. I work with a remarkable group of people who make me much smarter than I am.

And so Charlie Liberman who the director of the lab at the Massachusetts Eye and Ear Infirmary has done a great deal of the beautiful images that you saw in these slides.

We have graduate students who have been looking at some of the responses of single nerve fibers in ears that have been exposed to noise.

And then the people in my lab who really do all the hard work are my technicians, so, thank you very much.

[ Applause ]

>> Excellent.

>> Thank you very much, a comprehensive and complicated but very interesting presentation. We will have time for a general discussion at the end of all three papers.

But if there are specific questions related to Dr. Kujawa's talk we'll be happy to entertain them.

Otherwise there will be time at the end.

Somebody has a question.

>> My question is, I have two cochlear implants and so I thought well, my hearing is as damaged as it's going to get. But what I'm wondering is, as I see the cochlear implant is speaking to those nerves that you're talking about. So that means that it's not as damaged as it could get and that's what I'd like you to address for those of us that have the cochlear implants.

>> Well I think that's a very important question. Given the kinds of things that I've been talking about this morning and the specific focus of how the device that you use to communicate information to your brain, that could be a possible consequence.

I guess the general response to that would be, anybody should try and limit their exposure to loud noise.

First of all it's going to make your communication much more difficult, and so if at all possible you always want to optimize the signal relative to the noise. I don't expose myself to loud noise. I can't say I never have in my life, I think all of us have this evidence of a misspent youth thing going on, who knows what kind of long lasting impact that has on our ears. But your question is very relevant. My general answer would be, you need to be careful.

And I think that that extends as well to people who are using other devices, I think all of us have concerns about these devices how you handle them working in noise. Some people in this room may have to work in situations where there is noise and hopefully the occupational health programs in your setting are advising you about that and trying to help you make appropriate controls for your exposure.

>> I have two questions and they're a little bit technical.

First of all I wanted to thank you for such a wonderful lecture it was really, really a pleasure to hear it. The first one has to do with this. I noticed on the slide with the red dots that the frequency at which you were testing was 32 kilohertz which is far above anything that a human being would be doing so clearly you're using animal models.

But the question I have is this, is the recovery -- is the threshold recovery in the threshold damage frequency dependent? In other words, if you had exposure to a low frequency would there be a difference in the recovery rate than if you had an exposure to a high frequency in terms of amplitude, loudness?

>> Okay. So the question basically relates to where the damage occurs in the cochlea relative to the exposure frequencies. So, I use a band of noise. We know that when you expose an ear to a tone, for example, you're going to get the maximum affect at a place that is a higher frequency than the frequency of that tone. And something similar happens with a band of noise, it's just a little sloppier. But it moves basally, it moves to higher frequency as well. The question about what happens with a lower frequency of exposure is a really good one.

This is not a human model, we can't do this kind of work in a human. And so this animal has its best hearing at higher frequencies than a human. I can tell you that if I expose this model to a lower frequency band of noise, first of all the affects are smaller than they are at high frequencies. That's pretty consistent with what we know about the ear in terms of the base of the cochlea being the most vulnerable to virtually anything you do with it. When we look at hearing loss, we look at what happens after noise, what happens after ototoxic drugs. What happens in many forms of genetic hearing loss. It's the high-pitched end of the cochlea, the base of the cochlea that tends to show the biggest insult from those kinds of entities.

With a lower frequency of exposure it takes more sound for us to see this. We ultimately do see it. But it takes a louder sound. So I think that's just a vulnerability thing. The scary thing is we have now taken these ears that had the higher frequency exposure and when we looked at what was happening -- so the exposure gives you the biggest threshold shift up here, down here you have not much threshold shift. So we didn't look down there very much. But when we go back and look at those lower frequency places two years after exposure, they're starting to change as well. So there is not only this ongoing loss of neurons, of neural elements in the base you start to see it spreading to lower frequencies as well. So

that's a concern that is new -- we just completed a series where we looked at many different exposures, because the question is, is this just a mouse thing, the answer is, no. We see it in a number of models, and is it just a high frequency thing, and the answer again, I think, is no. Although you get the biggest affects in the base you ultimately get affects at lower frequencies.

>> I'll ask you another question later I don't want to take other people's time.

>> Thank you.

>> John, over here, yeah.

He asked my one question was about the 32,000 hertz. So that's good. What animals, they were mice?

>> Mice.

>> So, how about in humans where we have this predominance of low frequency subWoofers and cranking out the bass over the past ten years drives me nuts.

That's going to carry over in to the high frequencies?

>> Of course that's the million dollar question is, does this happen in humans.

And the answer is, we don't know yet. We think it's reasonable that it might happen in humans. It has happened in every mammal in which it's been studied so far.

And we know that in many other respects humans are very similar to other mammals.

>> If I could just add one quick comment regarding the question about the low frequency noise, one thing we know that even low frequency noise that has no high frequency complements to it still damages the base of the cochlea first.

So that region is susceptible even to the very low frequency of the Woofers that's true in humans as well.

>> I was going to say that as well that's not just in humans, so, if I deliver a noise exposure at one frequency band what we call a Tono-topically inappropriate change, no matter what we do, even the low frequency noises that I gave the mice I still got the biggest changes at high frequencies.

>> Let me suggest that we will have plenty of time at the end, some of these questions are relevant to the second two speakers as well. So perhaps for right now any other questions that relate specifically to this topic and we will certainly get back to the other people. We can't see very well so maybe the last question there's a question right here in the front that's been here -- go right ahead.

>> It was a wonderful presentation, thank you very much. I have a question about the use of amplification at appropriate levels of loudness so that I can function in normal, not particularly noisy situations. I often think that I'm 63 now, maybe I have 20 good years left so I have to save every nerve cell that I've got. And be very careful and I worry sometimes about the use of hearing aids as a source of inner ear damage. And if that worry is well founded my question is, wouldn't that argue for more serious and rigorous programs of aural rehabilitation beyond technologies, listening strategies and coping strategies, training speakers to deliver the signal in a way that we can access the signal without turning up our hearing aids to their maximum level of volume?

>> Again, this audience is giving very insightful comments, I don't know if any of the other speakers have specific bits they want to contribute to this. Certainly, I'm sure you know this, all of us have worried about that at some point as well. We know that hearing aids can produce at least at some points they have been able to produce sounds that are exceedingly loud. We have instituted things like output controls on hearing aids to try and reduce that possibility. People have specifically studied whether or not amplification can lead to long term changes in hearing, I don't know if you have more insights on that than I do.

>> Actually I think that the question is a very excellent one, I recall 40 years ago when I first got to Central Institute for the Deaf a person named Dick Silverman, some people may recognize that name, was long before cochlear implants and I said, Dr. Silverman how can you present such loud sounds to these deaf children and risk their hearing because I was a scientist, I didn't know anything about the real world. He said, it's because we have to. We have to be able to generate enough sound to stimulate the receptive system but then we have a responsibility of limiting it to just that that is necessary.

So I think that your point about appropriate rehabilitation and making sure that you don't have the hearing aid set with too much of a gain, being sure that it's appropriate for the environment you're in, are all very relevant.

>> >> Once again there will be plenty of time -- there was one question down here in the front row you've had your hand up so --  
[not on microphone]

>> Can you hear me? I was born deaf. I was never exposed to noise, I found out that I was born with deformed cochlea have you ever -- wondered -- have you ever gone to research about under-developed cochlea? I was born with a deformed cochlea.

>> Let me tell you what I think I understood. You've not been exposed to noise. You have -- your hearing loss is related to cochlea that are malformed, right?

>> Have you ever run in to a situation of an underdeveloped cochlea?

>> So, yes, I mean, certainly we have patients who have changes in the morphology in the structure of their cochlea that's responsible for their hearing loss.

I think the kinds of things that we will be talking about today are basically relating more to situations where we're looking specifically at a system where inner hair cells and nerves are communicating with each other and trying to protect the integrity of that communication.

>> Just a quick comment. Ma'am, are you a cochlear implant user?

>> I had a cochlear implant ten years ago.

>>> Just the general comment regarding the cochlear implant and question that happened earlier, is remember that Dr. Kujawa was talking about the nerve fibers that come from the -- that are stimulated by the inner hair cells those inner hair cells produce an excessive amount of neurotransmitter that then is toxic, as she said. The cochlear implant actually stimulates the nerve directly and by passes those

receptors. So you really don't have the problem of excitotoxicity. She's the neuroscientist. The people that are asking questions about high level stimulation with a cochlear implant, remember that the implant stimulates the nerve directly and bypasses that inner hair cell.

With my apologies to the people still standing, we will reopen the discussion at the very end of the three presentations. I want to make sure that all three presenters get appropriate time to give their talks.

The second talk is mine, and I'm going to step out of the laboratory a little bit and in to the media and I'm giving a talk called, *The Epidemic of Hearing Loss in Adolescents: Opinions versus Data*. This talk was precipitated by a discussion between me and Dr. Gates after some news headlines that appeared in the national media and in some of our professional organizations about a couple of recent studies that suggested that kids were really at an increased risk of noise-induced hearing loss and that there was quote, "an epidemic."

I agreed to give a talk on that topic, when I began to prepare the talk I realized that it was pretty boring. And so I thought I would add couple of other topics here today, I do want to address the epidemic issue, but I also want to make this a little more enjoyable.

Because I learned when I was about 50 years old that I was born with ADD, with apologies in advance I'm going to take a Whitman sampler approach through some issues that I think are important and relevant related to hearing loss in children.

First thing to keep in mind is that we are exposed to excessive noise from the moment of our birth. And in fact even before our birth there's noise, intrauterine noise, but may not be quite so loud. I chose this photograph - it's actually from a *Parade* magazine article about iPod exposures in kids from several years ago. But it shows babies in a neonatal intensive care unit that are being played, according to the article, Russian music which was said to pacify these infants and make them more comfortable when they were in the NICU.

My concern about that if that's really loud sound these young infant ears might be very much more susceptible to noise than older people. So I want to talk a little bit about that today. Here is a quick synopsis because I'm going to go in so many different directions I thought I better give you a few take-home messages at the very beginning.

I'm going to evaluate recent articles that were published that suggest that there's an epidemic of hearing loss in youth and statements that are made by some professionals and by our national organizations. I'm going to compare the findings with earlier national surveys conducted back to the mid 1960s and then I'm going to present two industrial surveys of hearing of new-hires, people just gotten their first jobs in industry who are 18-21 years of age. The take home is that adolescents hear better today than their parents or grandparents did when they were young. Not something that I expected to find but that was there.

The second is we'll talk about some potential sources of noise-induced hearing loss in children; we've just completed a study of transport noise, pre-term infants who were born prematurely and transported by helicopter to St. Louis children's hospital, talk about MP3 places and mention impulse noise, hunting and target shooting because that's an important message.

The hearing is better in children these days, they are still at risk of sustaining noise-induced hearing loss we all should be educated about hearing conservation practices.

So it doesn't mean just because kids hear better today doesn't mean that we should not bother to inform them and help them protect their hearing because as you all know, hearing loss from exposure to noise is really cumulative and ubiquitous and accumulates from all sources of exposure throughout life.

The third is, I thought it might be worthwhile to just summarize how many kids and youth in the United States are affected by hearing loss of all types. It was a little hard to find data; I looked through the data on population estimates and reviewed the progress of universal newborn hearing screenings and follow-up diagnostics and intervention.

We're doing a great job of screening newborns, but we're pretty lousy at providing feedback and follow-up and appropriate intervention.

We'll talk about that a little bit.

Finally I'll make couple of final comments, the take home message here is that noise-induced hearing loss is preventable and other children who are deaf and hard of hearing can benefit from early access to sound and speech through appropriate intervention and rehabilitation.

So, what about this "epidemic"

What fueled this fire? There is a National Health and Nutrition Examination Survey that is conducted by the government and it used to be done every ten years or so and in 2005 they started doing it every year. These are called NHANES III that was published of hearing levels of children in 1988 to 1994 and the National Center for Health Statistics in 1994 published that, and then the National Health and Nutrition Examination Survey in 2005-2006 became available online.

Now that's kind of dangerous when all the data are available online that anybody can study them, it used to be really hard you had to write the government and get copies of the papers and so not as many people did it. But as a result of the survey that became available in 2006 two groups actually from the same place, colleagues of yours, I believe. They're from Mass Eye and Ear Infirmary actually produced two different reports that were analyses of the same data set.

And the reason I mention that is the two different reports had different findings which I think is interesting that the staple data can lead to different findings and it's one of the points of this talk.

So these are the -- actually were three papers the two that were published in 2010 are on the left and center here then there was a previous study in 2001 of the NHANES III data.

All suggested that there was fairly high prevalence of hearing loss particularly noise-induced in children. I'd like to take a look at these papers just a little bit and the reason that I'm taking a look, although admittedly just a bit boring, is that there was a lot of media response to this.

And I can't read this at all, I suspect that you may not be able to either.

But the first one is from the ASHA Leader, the American Speech-Language-Hearing Association article called *Teens at Risk: Where there is epidemic of hearing loss related to noise exposure*" article on the right hand side, article published recently after that -- in the "Washington Post" and basically these articles suggested that hearing loss was on the rise, there were statements in all of the articles from professionals saying that we expected this, and this just means that we have to redouble our efforts to protect hearing in children.

When I looked at the articles, I questioned whether there really was such a great increase in hearing loss and I looked at them in a little bit more detail.

This is the teens at risk article. Let's just take a look at the papers. The first one is by Shargorodsky in the Journal of American Medical Association. They compared recent data in 2006 to the 1988 to 1995 data; they looked at essentially the average high frequency hearing loss. Dr. Kujawa mentioned the audiogram and showed you low and high frequencies.

So what he did, they averaged the high frequencies that are related to noise exposure and then they called hearing loss anything that was greater than 15 db hearing level.

That became a case of -- what they call a case of hearing loss. What they're findings were, was that the prevalence of hearing loss in children 6-19 years of age was actually 19.5%. And compared to the data that were published in 1988 to 1995, those studies showed that the prevalence was 14.9%. So remember those numbers.

14.9% went up to 19.5%.

And the way that that got reported was there was a 31% increase. The focus was on the increase rather than the absolute amount of hearing loss.

Another finding that isn't mentioned very commonly by the media or by some of the professional organizations is that by far, most of those hearing losses were unilateral, that means that they are in one ear only. The other ear is normal.

One of the things related that we know about noise exposure, particularly noise exposure from things like iPods is that it affects both ears similarly. So the fact that 70% of the hearing losses were unilateral really is no indication that noise is potential cause of those hearing losses. The high frequencies were more affected than the lows and that's shown by Dr. Kujawa that is consistent with noise exposure.

Other thing that was in both studies, I think this is very relevant, not so much as a scientist but husband of the person who manages the birth of three populations.

The manager of the family center she has about 100 families that she serves; about 65 of these families are from very low economic and socioeconomic groups and another finding was that the hearing levels in the poor children were much worse than hearing levels in the more affluent children.

That's an important message for our professionals about where we provide services, we need to make sure that everybody has access to the kinds of interventions and kinds of assistive device that are available for some of us.

The conclusion there, that study, was that the prevalence was greater in 2005-2006 than it was in 1988-1994.

The other study was published just a few months later in "Pediatrics." This study used another measure they called noise-induced threshold shift, NiTS. Basically they looked at the notching pattern of the audiogram and high frequencies. You may recall that in Dr. Kujawa's audiogram some of them had a little notch at 4,000 hertz or 6,000 hertz.

The notch in an audiogram is often associated with noise exposure but it is not necessarily diagnostic or causative, there are lots of other causes of notches and people who don't get exposed to noise often do have notches.

They found that the NiTS, the noise-induced threshold shift, increased for females but no other changes were observed in the groups. This is the same data set as the other publication. Also observed that listening to loud music increased between the two studies, the self reports, these are surveys of representative sample of the population of the United States was done by interview and audiometric tests.

Each of the subjects was interviewed. And turned out that the kids 6-19 years of age indicated that they listened to personal listening devices and loud music about twice as much for about twice as long a period of time as in the earlier survey. That's just a few years apart. And fewer females actually reported wearing hearing protection, not certain that's relevant to anything here but that was one of the findings.

Their conclusion was that increased exposure to recreational noise and decreased use of hearing protection might explain the increased prevalence in females. Well this is one of these studies when I looked at it I thought, I can't think of a good scientific word for this, this looked a little flakey to me because seemed like 7 kids are using iPods more, why would only the females show worse hearing level and I couldn't explain that.

I think it's just a statistical aberration.

The point here is, I found this picture of a guy using a -- what do you call those? Metal detector down on the beach in Florida, if you look long enough to find something you'll find it.

I don't think this picture is very relevant -- very representative. This came from a company that sells these metal detectors. When I've been in Florida the guys carrying these are usually overweight like me and about my age they have a big hat on and they don't look quite as astute as this guy is. Let's just take a closer look.

Let's mine the data a little bit, take look at the articles and see what we can find from them. The Henderson paper was "prevalence of noise-induced threshold shifts in hearing loss." But the noise exposure was unknown in this case because these were just surveys of kids from a national health and nutrition study. Nobody asked them -- first of all they didn't work in occupational noise they were too young. No measurement of any kind of noise exposure. There was that one question I'll come back to it about whether you listen to loud music five hours a week or not.

Also, the title, noise-induced threshold shift, the doctor mentioned several graphs where she plotted threshold shift and measured the threshold in a mouse in that case then gave treatment like noise exposure then measured in. The change in hearing is a threshold shift. This was a national survey they only measured hearing once, there were no threshold shifts measured only one hearing test performed for each subject.

The threshold shift what they mean is that the thresholds of those children were a little bit different from the national norms, the zero line that Dr. Kujawa showed you on the standard audiogram.

This NiTS is a misnomer, I don't think it should have been used in the title but I didn't get to review the papers. They actually based their -- they based their definition not just on the NiTS idea but also on the characteristic of a notch, audiometric notch at 4,000 or 6,000 hertz.

This is also hazardous, because notches are everywhere, this graph is going to be hard to see, I can't use the pointer, but I -- I think it's okay, let me just take a look at this graph and there's a straight line across the center.

This graph actually shows the thresholds of a population that was studied in 1966 to 1970, of the -- of children ages 6-17 years of age.

And the parameter here -- so the vertical Axis -- Bill has that over there, thank you.

The vertical Axis the threshold in decibels with respect to that zero line. And then the lines on there, horizontal Axis frequency the lines on there represent the thresholds across the population. These are called percentile thresholds.

Pay attention just to the 50th percentile. If the population hearing levels reflected is national standard at the time then that line should be a straight line right across.

In other words, the zeros by definition are the hearing threshold levels of good hearing young people. That's how the American National Standards Institute defined it. But you can see with the actual survey of real kids that the thresholds differed from zero and they differed mostly at six kilohertz.

In fact, down in the 25th percentile of the population, you can see that the notches are even bigger. The point is that there's actually a notch that's in the distribution of the whole survey, it means that we really should change our audiometric zero, it certainly does not mean that hearing levels surveys of kids if there's -- just because there's a notch does it necessarily mean that they have bad hearing or that they have been exposed to noise?

I mentioned that, because it will be relevant in a few minutes.

Second thing that was strange about this particular study is they showed that the hearing level in the females got worse between 1988 and 2005. This chart is a bar chart, and it kind of looks like my 401(k) over the past few years, you see how it just keeps going down. It's a little more complicated than that, but I want to just draw your attention to the fact that on the horizontal Axis are different comparisons, it's hard to see it from here but on the left-hand side where it says NiTS, I think this is the relevant issue,

you can see that as the authors pointed out that the females, the prevalence of hearing loss in females went from about 11.6% up to -- 16.7%.

That was the significant increase, so their finding was that the prevalence of hearing loss measured this way ended up being worse for females. But it was not worse for the total population. These are the data for boys and girls. It wasn't worse, if the females got worse but the whole population didn't get worse, then that necessarily means that the boys got better. There's no other explanation.

And in fact if you look at the data you can see that the prevalence for boys actually went down from 1988 to 2005. So I think there's a little bit of a tempest in a teapot with all of the conclusions about this being an epidemic of hearing loss, certainly I can't think of any exposure that would somehow selectively damage the hearing of females or young girls more than it would damage the hearing of boys. It's just kind of counter intuitive.

I think that this is one of these challenges with the way that we look at large data populations. So, what can we really conclude from that study? Well, there really is no change of prevalence between 1988 and 2006. The data show differences for females.

There's no evidence whatsoever that the hearing loss was associated with noise exposures, overall prevalence of exposure to loud music did increase, it doubled but there was no change in hearing observed in boys and girls. So basically, the conclusion there is, noise ain't it.

It's not the culprit or if it is we haven't had long enough time to see in the data. And like other studies, the vast majority of these cases were unilateral. All right, what about the other study, the Shargorodsky study. They defined them differently, I won't go through the detail of this, they also both use the notch description, high frequency hearing loss averages compared between the two groups, there's recent paper that just was published by investigators from University of Minnesota that actually they understood the challenges that I mentioned about audiometric zero, they have shown up to 10% of the cases so defined are false, they're false positives.

So, the prevalence that I mentioned earlier was that prevalence increased from 14.9 to 19.5%. That was reported as an increase of 31%. Now, if we pay attention to the recent study by Schlauch, the true evidence of hearing loss in 1988 to '95 was actually 4.9% and it went to 9.5%.

So as a consumer we would say, wait, that's not quite so much of a problem because now it's less than 10% of the population, it certainly doesn't sound as bad as 20% of the population. But if we just look at it as change, as the percent change 9.5 is almost twice 4.9. So the correct statement you can put in the newspaper from this study, if you made that adjustment, is that the hearing loss increased by 93%. Because it's the problem of small numbers, if we brought it down to one person and then you studied 10,000 people one person had it, then you went back five years later studied 10,000 people and two people had it you could say that it increased by 100%.

So those studies are misleading and I'm concerned because the media and a lot of regular people just assume that we really have a bigger problem than we have.

I'm not going to take much time to go through this; this is basically just an example of how sensitive these case studies are.

This is a hypothetical group of 20 patients where we -- assuming that we could measure the thresholds to a one db accuracy these are 20 patients. They all have different thresholds. They vary from pretty good to a pretty bad one over there on the right hand side.

Now, when you have your hearing tested in a clinic, you don't get the results out in one db increments, they are tested in five db steps. So the actual reported hearing thresholds even though the true thresholds would be across that distribution you saw in the read, the reported thresholds end up categorized in groups. So, the one group is five db hearing level, 10, 15, 20, 25 and 40. The definition that the authors used for a hearing loss was anything that exceeded 15 decibels.

So in this case three of the cases, the last three on the right, exceed 15 decibels.

And so the prevalence would be three out of 20, or 15%. Now, let's assume that you tested them exactly the same again and just two people had a difference of hearing threshold, first test of the second test of one decibel.

You can see that most of these pink and red columns are the same height for the two tests but third one and fourth one from the right, one subject got one db worse, one subject got one dB better.

Now we do the same thing, and we do the five db step size now we find because of that one db change a fourth subject fell in to the 20 decibel category, became an additional case and now the case -- now the prevalence is 20%. That is an increase of 33%.

Even though there was only a one decibel change. That's the reason that it's important to look at entire database and to be careful about over concluding about risk.

I mentioned several factors that are inconsistent with noise exposure here and I think that these are -- it's clear that they're just not that 07% of the cases were -- 07% of the cases were unilateral. Especially MP3 players, which are worn on either ear, both ears, most people don't listen with one ear. No difference in prevalence between these two experienced noise exposures and those who didn't.

And -- it's not an epidemic. Perhaps there's a little snuffle in there, but certainly we don't have an epidemic of a hearing loss. Increase in prevalence if there is any, is really not related to noise exposure.

You might think I'm saying that this is really not a problem.

Well, it is. And I'll talk about that in just one second.

What I wanted to do then is to go back and see what we knew about hearing levels of kids historically. There actually is an Nhanes 1 that was done in 1966-1970 then the 3 which was in 19 -- the III, which was done in 1988-1994 and I'll show you the new hires in a second.

This is an audiogram, this is the data obtained for boys ages 12-19. The left ear measures and you can see that the hearing level is pretty good.

The poorest hearing sensitivity is about seven db at 6,000 hertz and they're all within ten db of audiometric zero. This is good hearing but seven db at 6,000 hertz.

So I went back to the 1966-1970, because I thought, is this worse than it was back in '66? These are the same data for boys 12-17 years of age in 1966 to 1970.

You can see that the hearing, particularly in the high frequencies the ones affected with noise, but noise is significantly worse. In fact the hearing threshold level median was close to 15 db in that group. So that was a little bit surprising, because -- actually kids hear better today than they did in 1966-1970.

I found some old data back to the 1940s which suggested that hearing just continued to get better in kids, I think that's really not surprising if you think about the fact that kids are healthier, they have better nutrition, if you look at state high school athletic records they're all better now than they were 1990 and 1980. They have better hearing in this case.

These are data from the National Institute for Occupational Safety and Health on the horizontal Axis is years. The years that the data were collected from 1970 to 1986 and on the vertical Axis are the audiometric thresholds and then the different colors represent the different frequencies. So, first of all, what you see from that is across the Board. It looks like these lines go straight across from right to left. Even the lines at 4,000 and 6,000, the blue and the red dots show really no change.

These are pre-employment audiograms for 14,1686 individuals who are 20 years of age and who just hired in at one of 23 companies in the United States who had hearing conservation programs and who provided their data to the National Institute for Occupational Safety and Health. Between 1970-1986 it looked like hearing hasn't changed. Then this is a paper that was published about two years ago and this -- not two years ago. I'm getting old. Six years ago, pardon me, just seemed like two years ago. And this shows same thing from 1980 to 2004, this is for workers at the Alcoa aluminum company.

You can see the low frequencies didn't change, high frequencies got better just by a little bit. So, both studies show that there really is no change in hearing sensitivity but this does not mean that kids are not at risk of noise-induced hearing loss.

Remember that iPods and personal listening devices are very, very common these days, usage has greatly increased and as Dr. Kujawa mentioned the hazard that is posed by these devices and by any noise exposure to a combination of how loud it is and how long you listen to it.

The devices today are quieter than they were 20 years ago. The industry has added output limiting on the iPods so that they don't produce the very high sound levels that they actually did when they were called "walkmen" and larger. They are quieter but the kids are using them for much longer periods and some studies that show that some kids listen more than eight hours a day to these devices. That is a lot of duration, which increases the overall exposure. It does present a hazard but it only presents a hazard for some listeners. I think Brian Flygar has done the rest research I suggest that you Google him you'll find lots of information about iPods.

He has a little "60 rule" which is, I think, a very appropriate suggestion that kids should try to keep the volume level to about 60% of maximum and listen for not more than about an hour a day.

Many do more than that, but I think there's not a significant risk as long as they do, listen at very high levels. The other is, I just personal pet peeve of mine some people like to use the ear phones that fit down deep in the ear canal block out external sound.

The argument is that you can play these devices at a lower level if you don't have that masking noise of the external environment around it.

I'm opposed to that, mostly as a parent because -- I think Bbill might have comment about this related to hearing protection, there's always a risk that you will not hear a warning signal if you block out the external sound. And workers don't like to wear hearing protection when they think there is some dangerous event that is -- that they can be alerted to. Think about your kid getting off the school bus and walking across a busy street, you really don't want to reduce the opportunity of -- for him to hear an automobile approaching.

So I think you should wear ear phones that leave sound outside, inside and balance that risk. I'm not certain you can read this. How many children are deaf or hard of hearing?

I wanted to just briefly mention this. This is actually is from survey that was done by the National Institute on Deafness and Other Communication Disorders. And it was -- I modified it to make it relevant to current population statistics, I thought this might be of interest, because we're talking about risks in the national surveys of every kid but really our focus is on the kids who have a hearing loss that is significant enough to impair their ability to have a successful life.

And so this divides the groups up in to age ranges from zero to 19. Then in the blue -- the green are total population estimates. There are about 86 million kids ages birth to 19 in 2011.

The blue are the essentially the bilateral hearing losses that are now found, severe, moderate and mild. And you'll notice that there are about -- I cannot read the numbers from here there are about 86,000 kids who have -- who are zero to 19 that are profound then another 25,000 that are severe. The big thing here is that we've ignored unilateral hearing losses I think for a long time. And you can see that unilateral hearing losses are almost four times as prevalent as the bilateral hearing losses. There are more than six million kids in the United States by survey who have hearing losses that are either unilateral or bilateral, mild, moderate, severe and profound. This is a significant number of kids in the United States.

Part of the reason that we have them identified is we're doing much better at screening children and screening children through the universal newborn hearing screening programs that are provided in all 50 states. These programs probably everybody knows is -- they are provided usually in the hospital before the neonate is released from the hospital, and they use objective tests, the otoacoustic emission and Abr test that Dr. Kujawa mentioned.

In the United States about 95% of infants born in hospitals are cleared. Recent data now suggests that about 50% of those kids are lost to follow up, either the parents don't follow up and don't get a second test, those that get referred. Or commonly professional may tell them not to worry, because the incidents of hearing loss is so low that it's probably a mistake, probably a false alarm. That's actually true, 19 out of 20 times.

But the challenge is for the one kid that you miss because they don't get back for follow up. I think we have a really important job as professionals to provide better follow up and better comprehensive care for all of the kids who are referred on the initial screening, that's where our services are falling down right now. Finally I wanted to just take couple of minutes and talk about early source of noise exposure.

Because the rest of this stuff I just talked about I think is kind of boring I wanted to make it just a little bit more interesting. I told you that we can get exposed to noise very early and in some infants that

exposure can start at the moment of birth. St. Louis Children's Hospital maintains an active transport team of nurses and surgeons and also pilots who bring very fragile neonates to the children's hospital for emergency services. These neonates are transported because they're in life threatening conditions, extreme prematurity and need to be treated rather than at rural hospitals around Missouri and Illinois, at Children's Hospital.

There are three modes of transport: ambulances, fixed wing aircrafts and helicopters. And most commonly used at children's hospital are helicopters so this is the kid copter. And this project actually started because the transport nurse came to me, she knew that I knew about noise exposures, and she said that she thought that there might be over exposure to these sick neonates who are transported in these helicopters and she wanted to do some noise surveys. I didn't want to loan her my expensive equipment I was concerned that she didn't know how to use it and I also wasn't certain it was a big problem. So I told her to go Radio Shack and buy a \$40 sound level meter, bring it by and I would calibrate it and we'd stick it on the helicopter see how loud it was. She brought the Radio Shack meter to me, I got a screwdriver was adjusting the sensitivity on it to calibrate it to my expensive machine, I broke it. And I told her to take it back to the store and tell them it didn't work. She said, well, that's a lie, no, it isn't, it doesn't work.

You just bought it so she went got another sound level meter, we calibrated it and I turned out it was surprise because exposures are really pretty high in these neonates.

We did a noise survey, because we learned that these fragile neonates are transported sometimes for couple of hours in the helicopter to children's hospital and they are often given gentamicin, a small antibiotic just protective level before transport to protect them against infections while they're being transported to the hospital. We weren't certain whether that was a problem or not.

Because we know from our animal studies, from the mice studies like those that were talked about that ototoxic antibiotics combined with noise actually exacerbate the noise-induced hearing loss, well nope that if you get a drug that -- ototoxic drug then get exposed to noise you get more hearing loss than you would have gotten with just the noise alone.

So we thought we might need to tell the physicians not to give them that gentamicin before the transport. Then if we actually got the noise measures suggested that they were exposed to too much noise we felt like we should see if there's some way we can protect their hearing.

So, just about one minute I'm going to go through the study that we did, this is the helicopter just prior to transport that's not a real baby there, it's a doll that was done for the photograph. But you notice that everybody there is wearing ear protection except the baby and me, I don't why I failed to put it on that day. I think what happened is, everybody standing there said, give Dr. Clark helmet No. 13. And they all started laughing. I said, why am I supposed to wear helmet 13? They said because Emily threw up in it yesterday we had really rough flight. We think you should wear that one. I didn't put it on. We did do noise surveys in the Isolet while the helicopter was being transported this just shows you how we did it. We put microphone not on the baby, but we actually had it inside the Isolet then made measurements every 30 seconds during the transport across.

Here are the results of that, this, the X Axis is the duration and the 30 second sound levels you can see that when the helicopter actually -- when the noise levels go up on the right that's the baby approaching the helicopter. Then the helicopter takes off, and the level is pretty constant during the flight. This was from Effingham, I will toil St. Louis about a hundred miles. You notice on the right hand side there are three little peaks, these peaks are when the transport team had to do something with the baby and opened up the Isolet there's really a lot of -- about seven decibel difference but overall levels of exposure are all above 85 decibels. Measures we made ranged from 85 to about 94 db on flights.

It's clear that these babies are given too much noise exposure and earplugs just don't work. The earplugs that are only pediatric earplugs that are available are called these minimuffs they provided about seven decibels of sound reduction. But they -- these can't be used in these fragile neonates because the fragile neonates have such thin skin these are stuck on by double-sided sticky tape, if you pull earplugs off then the skin tears, we need a better solution than that. So, we concluded that it was too noisy, that earplugs were not the solution.

And we still needed to know whether that gentamicin potentiated the noise-induced or not and that's not a study that you can do on these infants because they were in such serious medical condition we could not stop to do any kind of a study. So we went to the laboratory and that's the final little point here is we turned to our colleagues, Kevin and Elizabeth to do a mouse study. And address the clinical recommendation about eliminating gentamicin.

So we wanted to see whether that mouse exposed to noise and given an antibiotic would have more hearing loss than the mouse that did not get given the antibiotic before the noise exposure. So that was our hypothesis.

Long story, very long story short these are the baseline thresholds of the buys prior to any kind of noise exposure or drug treatment. Basically what we did we said, we wanted to get a drug treatment that would not cause a hearing loss. We found one, the blue line is mice that had the drug treatment of gentomyosin -- which is like gentamicin, it caused no change in their hearing sensitivity whatsoever. So we knew that the gentamicin itself wouldn't do anything.

Then we took a group of mice and we exposed them to enough noise to cause a noise-induced hearing loss and that's the red line, this is threshold shift just like Dr. Kujawa showed you the mice sustained about 30 decibel noise-induced threshold shift.

The question is, what would happen when we combined the drug with the noise.

And we had predicted a potentiation like the blue line here would indicate that the drug and noise were worse than the noise alone. That's what we thought would happen.

So we did the experiment. And here's what happened.

There was no change in hearing sensitivity whatsoever, in fact the gentamicin blocked in this particular mouse. And the hearing level of the mouse that was given the drug before given noise exposure to exactly the same as control mice. So, in this case it was very surprising that the drug actually prevented all that have noise-induced hearing loss.

The real question then is, how do we protect the hearing in these babies? Is it plugs or drugs?

Certainly we knew that the gentamicin was not dangerous to these babies on the basis of this and another group of studies that we are carrying out right now. But we do need some better hearing protectors for the babies while they're out there and working on this trying to invent knitted caps that they could wear, have also talked about something I called kind of, hypothetically the Bose quiet comfort incubator, you know that you have headphones that can have active noise cancellation in them, these babies have small heads. We may be able to design an active noise control system inside the Isolet that would protect the babies much we're now completing the work that is about the boundary conditions of susceptibility, what genes are involved to really understand what causes that inter-action.

And this really is a good example of the partnership between clinics and basic scientists and reflects well the value of our mission which is really to try to provide the very best intervention for children who are deaf and hard of hearing.

And these are some of the kids from the Central Institute for the Deaf on a celebration of our graduation last year. So, I'll stop there say thank you and address a couple of quick questions.

[Applause]

If there are none, we're going to -- I'll go ahead introduce -- somebody is coming.

>> That was an absolutely fascinating study and my children and most of my grandchildren all wear hearing aids as I expect most of the people in this room do.

I tell my hearing kids not to wear an iPod; the hearing children we put hearing aids on are getting 30-60 decibels of increase sound all the time. Is this inconsistent -- what are we doing to these kids?

>> The question is about wearing an iPod over the top of a hearing aid?

No, wearing hearing aids at all increases the sound far more than the iPod does. Don't wear the iPod but it's okay to wear the hearing aid.

It's a continuing challenge for hearing professionals to say, stay away from noise but listen to noise through your hearing aid. I think the answer is really the same one that Dr. Kujawa and we talked about earlier is to get enough gain, to get hearing aids to get you to your most comfortable listening level and make sure that there's not any over amplification. But certainly I think that in general the way that hearing kids use their iPods the amplification that most of them use are not -- not quite as much as severe to profound loss.

Can you -- I'm the lab scientist she's the audiologist I want to make sure I've giving proper information -- thank you.

I can't see maybe over on this side?

>> When you spoke about the inner hair cells and outer hair cells, the inner hair cells actually communicate by nerve to the brain but outer, their purpose is to amplify the sound, correct?

>> That's correct.

>> So the hearing aid is doing that by amplifying the sounds and some of those outer hair cells are damaged amplifying for them to help stimulate.

>> That's correct.

>> The iPod itself, if a person has normal hearing, actually could be doing damage if they're listening to it too loudly?

>> Well, the amplification that's provided by the outer hair cells is most useful for very soft sounds. It's because of the nature of the decibel scale when you get up to sounds that are 70, 80, 90 decibels then mechanical response of the cochlea is dominant factor the outer hair cells don't provide very much additional gain. Is that a fair way to say it?

Really, if you think about it, what happens is those outer hair cells, the activity that they provide really helps your ear become more sensitive to soft sounds, so when a sound is ten db or 20 decibels, what's happening is your inner hair cell really can't hear it, but that outer hair cell provides gain to the sound from the outside that helps the inner hair cell hear the soft sounds. When sound gets up above 40, 50, 60, 70 decibels response of the inner hair cell in the Basilar Membrane it's high enough that that little amount of gain that the outer hair cells provide is Infinitesimal. That is the reason it's not really relevant to the high levels of sounds that are provided through the iPod or any of the others. That 30 decibel gain doesn't happen to high level sounds just happens to low level sounds.

>> Thank you very much.

>> Once again I can't see.  
Over here?

>> With the type of my hearing loss, sensorineural progressive, severe to profound bilateral currently, scientists say that hearing aids and cochlear implants refer the damage to residual hearing, especially when my hearing continues to plummet as it did 27 years ago when I was told by my audiologist and ear doctor to stop wearing any hearing aids regardless of how adjusted they are. Please explain. What's going on?

>> I didn't hear the first part of the question.  
Did you?

>> So, you are an implant user right now?

>> No. The doctor said that I have a possibility for one.

>> Well –

>> It makes me suspicious because I've been hearing a lot of people say that the cochlear implants are extremely loud. In that sense you talked about extremely loud noises can further damage person's ear hearing that they already have.

>> First of all there's a difference between patients with a cochlear implant hearing something extremely loud versus how loud an actual sound is. In other words, there's a mapping process that your audiologist should be employing that maximizes the sensitivity of your auditory nerve to the implant, electrical stimulation and if that's not set properly then the implant can sound too loud.

That's a little bit different than having very loud sounds from the outside driving the implant and it's my understanding, I don't map implants but it's my understanding that there is essentially a dynamic range adjustment so that the implant set so that it does not over drive the electrodes as part of the mapping process.

I think the other part of your question about asking about whether wearing a hearing aid can continue to damage your hearing, that's been a question that's been with professionals for 30 years or 50 years; we've talked about it earlier. I think the issue really is to balance the amplification that is needed to perceive sound in a useful way without over amplifying it.

Just kind of living with it, I think that most people now feel that the value of wearing a hearing aid exceeds the risk of the hearing aid causing additional hearing loss. There's evidence from scientific studies that there can be some additional hearing loss caused by hearing aid use. But for subjects with very severe to profound hearing loss, the additional hearing loss is not really a lot. So the benefit of the hearing aid exceeds the risk. I think that's the recommendation. Am I correct?

>> Another question.  
One more question.

>> There was an instrument that doctors used to detect hearing in Fetuses in the mother's uterus before the baby is born. I've read a little bit of that article, this was about 40 years ago in "Newsweek," the title is, when the fetus isn't listening. Why are these tests discontinued? This is before the baby is born. They put the instrument that looks like a doctor's stethoscope to listen to the heart. Why is that discontinued?

>> So, I'm aware of studies -- my microphone is not on?  
I am aware of studies that have tried to assess what an infant can hear in the uterus. I think that those studies were done with a different purpose; it wasn't to test the infant's hearing -- like we do in newborn screening. People wanted to know what kinds of sounds infants could detect in uterus.

We have excellent ways to assess the hearing of a newborn after the baby is born. And in fact virtually all states here now have newborn screening laws that require us to test the hearing of a newborn before they ever even leave the hospital. So we've made dramatic leaps in our identification of newborns with hearing loss. Because we test them basically using the same kinds of tests that I used on those mice it doesn't require a response, an active response from the baby and we get very high quality information about the status of that infant's

hearing, much better than we could if we were trying to assess what they were hearing before they were born.

>> Thank you.

>> I think some of those early studies use sounds that were delivered directly to the abdomen of the mother and remember that the mom is a pretty good hearing protector for the fetus it's hard to get a lot of sound in there and move that fetus around.

With the tests that Dr. Kujawa tested the otoacoustic emission test just after birth, you have to wait until the fluid clears out of the ear. When the babies are born they actually have fluid in their ear and it has to clear out or you can't conduct those measures. Those are very sensitive measures but really only work after birth. Maybe we can do one more then let's go on to the final talk.

>> Sir, I just want to touch base on something that you quoted but you never really got back to, you said that you guys were "lousy" about providing intervention for kids and children who are deaf or hard of hearing, hearing impaired, whatever.

>> Yeah.

>> Why is that?

How are you guys doing -- how are you guys getting better at that?

>> There are couple of reasons why I said that and used the term "lousy", the first is that in our profession we have patted ourselves on the back for doing such a good job of implementing very early identification. I think that's a great stride that the doctor just mentioned, it's mandated in all 50 states, we are really doing a great job of doing the first test of kids since 95% of kids born in hospitals are screened. But there's a lack of appropriate services for follow up, just even to follow up and identify which of the kids who are called on the screening actually have a hearing loss.

And then there's general lack of services that are available, particularly in rural communities. So a family has a baby in a hospital, the baby refers on the hearing screen they have to drive 290 miles to a local metropolitan center in order to even get the child evaluated. The pediatrician tells them, well, 19 out of 20 of these are just false alarms anyway. So they decide to wait and then don't really find the case of the child who has a hearing loss until much later. The age of diagnosis used to be three years.

Now it's three months.

What we've not done a good job of is making sure that the services are available to everybody. I think that's a governmental issue, that's a regional issue, that's also a professional issue. For example, in my state of Missouri, there are 36 people who specialize in pediatric audiology. 35 of them are in St. Louis. One is at the state school for the deaf and none are in any of the rural communities.

That's what I mean by doing a lousy job of providing our services. I think that the profession needs to develop more audiologists who specialize in pediatric audiology, because what you think about in the profession is, selling hearing aids and dispensing hearing aids; those are what makes a lot of money.

>> Thank you.

>> But the pediatric audiologists are the ones who need to be trained. Let's go on and then we'll open it up again for discussion at the end of Dr. Murphy's presentation.

So the third presenter is Dr. Bill Murphy, captain in the U.S. Public Health Service and his title is called "impulse of noise exposure in the workplace, sources and assessment." Thanks.

>> Thank you, it's a real privilege to be able to come to speak to you this morning, I want to note my coauthor on this, Mark Stevenson, he is a retired lieutenant colonel from the Air Force that's why we have this beautiful picture of the airplane just transitioning in to a shock supersonic motion.

I work for the National Institute for Occupational Safety and Health. That is part of the Centers for Disease Control and Prevention. And when we were formed in 1972 as part of the Occupational Safety and Health Act, we were designed to do research in occupational illnesses and injuries, OSHA was designed to do research or actually do regulatory work with industry and labor.

So, when you see this, we're not Niosha we're not our friends at OSHA. We're the national institute for the occasional study of hearing. Not really.

Like Dr. Kujawa I have a great affinity for the Deafness Research Foundation, because in my first three years as graduate student studying physics and doing research in auditory elements and research, I was funded by a project through the Deafness Research Foundation to look at ways of calibrating sound delivery for high frequency audiometers.

So what is it that I'm going to talk about today? A little bit different than what's in the brochure there. We'll be talking about hearing protection, talking about applying health communication to motivate workers in preserving their hearing. I have a lot of research experience in the field of hearing protection devices and then most lately work that we're doing in hearing protection fit testing.

Determining whether or not that your hearing protector is working for you as a worker is a priority. So, how large is the problem that we're dealing with? About 30% of workers or persons attribute their hearing loss to work related noise exposure. It is the most common self-reported occupational illness. If we look at data from the Bureau of Labor Statistics, this is from 2006, they have had data since 2004, what we find is that 24,000 workers were reported by the Bureau of Labor Statistics for having occupational hearing loss. And this is a significant threshold shift. This is a change at three frequencies of more than, I believe it is 15 decibels or is it ten? Ten. I don't do the audiology side too much.

When we look at issues with civilian hearing compensation within the military, the Department of Defense, Army, Air Force, Navy, Marines, we have throws to 6,000 persons that are being awarded on an annual basis. If we look at what the Veterans Administration expended in 2006 it's 1.6 billion dollars for veterans who had hearing loss or tinnitus as primary disability. If we look at this in terms of dollars for compensation for the civilian population in the DOD it's close to \$30 million.

So what? We're all going to lose our hearing as a function of age yeah, right?

It doesn't have to be that way. Here is some data we've collected from the study that we did with United Brotherhood of Carpenters, by age 25, we see the hearing loss or hearing thresholds of a carpenter age 25 and when we compare that to a healthy individual, 50 years of age such as myself, this is about what we see. They're very close to one another. But when we look at that same carpenter and that same group of carpenters this is the kind of hearing loss that they experience. It's significant.

In the occupational safety and health realm we have a hierarchy of controls comes to the industrial hygienist and such. First we want to eliminate whatever the hazard might be, if we can't eliminate the hazard then remove the worker from that hazard. If we can't remove the worker from the hazard then we do something to protect the worker.

Anyone care to take a guess as to what order we use in noise exposures?

We turn it upside down. We throw hearing protection at the worker we say, we've done our job, they have got something that they can control the noise and eliminate the risk.

Well, protecting the worker is not equivalent to wearing hearing protectors. My apologies to Grant Wood, who I believe is the painter of this. So, in 1979 this is just a quote that Mark has used from his work in the Air Force, "the science of hearing protector technology is mature". There's a need to fund additional research on hearing protectors.

I don't know how many of you saw Dr. Bauman's hearing aid museum out in the display area yesterday. I see several of you did. This is -- as I saw that I was thinking I wonder what the hearing protector museum looks like. This is the first active noise reduction headset, your Bose quiet comfort headset I see the stenographer over here is using that as a way to listen. And it's huge. It's got vacuum tubes, it's got an extension cord and you're not going to be able to carry that thing around.

In 1986 he flew the voyager aircraft, and one of the things that he wore was a David Clark active noise reduction headset. One of the first systems that's out there, there are several providers of aviation headsets that have active noise reduction as a function of their features. This is research that's being done now by the United States Air Force and United States Navy looking at a way to generate a hearing protector with 50 decibels of noise reduction capability from 125 hertz to 8,000 hertz. If you look at this near the ear drum as a microphone, and a speaker and it's being used to generate an anti-phasic signal in the small occluded volume between the end of the ear plug and the ear drum. They're able to push the limits of noise control or active noise reduction out to 3,000 hertz.

That's fantastic, these things work and they're now being fielded and being manufactured by a company in Blacksburg, Virginia. They're in the area of your father's earplugs, folks. There are all kinds of things out there that are brand new. The one that's on the top there that looks like a custom molded product - that's a musician's ear plug. It was developed for the Chicago symphony orchestra to protect violinists from their own playing that they're doing. The one to the left of that are mass produced sets of musician's earplugs that give a flat amount of attenuation.

The yellow and green earplugs are now what are being issued to our service members who are going in theater in Iraq and in Afghanistan. And it's a nonlinear level dependent hearing protector. The other ones, well, we'll get to that in just a moment. They're not your father's earmuffs, either.

The one on the upper left corner those are again a level dependent earmuff, they're meant for hunters and shooters. You can hear when you're listening but when you fire the gun, the product has a different amount of attenuation. We have electronic earmuffs.

I had a discussion with a person on the flight out the other day, yesterday in fact, out to DC he was telling me about what he wears -- not quite the gray earmuff there; it's different version of those, but he wears those as he works with inmates in the federal bureau of prisons. He was saying the great thing about them is, I can hear what the inmates are talking about, of course the inmates are wearing normal earplugs and they have to yell because they're in a noisy environment. They don't realize that they're telling him that they're going to steal that piece of metal over there or they're going to do this to so-and-so over there. He's got a leg up because he can hear what they're talking about. There's a protector for just about every situation.

The National Institute for National Safety and Health is an electronic compendium in that we have almost 400 products now that are listed as having different manufacturers. If you can't find a protector that you like, you probably haven't looked. So, there are new devices that are continually emerging.

The problem we run in to is how do we get people to wear them, how do we get them to wear them well? Here is an example of a plot when you look at the back, gold bars in the back, those are the noise reduction ratings of a bunch of different products, guys on the left, bars on the left are earplugs, the bars on the right are earmuffs. And the bars in the front are the values that we see when we go out in the field and try to assess what somebody receives. They're just not making it. They're not getting the amount of attenuation that they should. This is what happens when you don't wear your muffs and plugs appropriately throughout a work shift.

If we just take the top yellow line there, we'll see that after 15 minutes of not wearing it you've gone from a rating of 25 decibels down to 20 decibels. If you now wear it for only half the day you have gone from 25 decibels to five decibels. There is a myth, show me a good regulation; put your rules in place and we'll reduce the amount of hearing loss in the workplace. That doesn't work.

In 1997, I think it was, when we did this study we worked with the United States Air Force base in Dayton, Ohio, we went and surveyed workers who were in the power plant facilities. Now these are civilian workers so they're under OSHA rules, they're civilian workers who are under the Air Force's rules and they're civilian workers who are under the DOD's rules, three sets of rules that these workers are supposed to be obeying. When we consider the amount of time that they're wearing their protection, this is simply walking around and watching them over several times that we visited, for those workers who had a significant threshold shift or standard threshold shift roughly 25% of the time. For those who did have a significant threshold shift only about a third of the time are they wearing their protection. So, you laugh.

A number of years ago I went to Worcester Polytechnic; I gave a talk to a bunch of high school students. I put earplugs, yellow foam earplugs out on the table for each of the desks of the students. And some smart aleck in the back row had them in his nose, I kid you not. Any protector that can be worn will be worn wrong because they don't know how.

We worked with the United Brotherhood of Carpenters to implement a health promotion model applying different things with social psychology and principles of how to educate and motivate people. What we need to do is to make them aware of the problem.

We have to find out whether the problem is relevant to them, we have to find out whether it's important to them and then lastly, if you haven't achieved the first three how can you get them to do anything about it.

Part of the approach to this research, it was actually just published this year in the *Noise and Health Journal*, a 28 item survey tool to identify attitudes and beliefs and importance of good hearing. We identified behavior barriers to keep them from doing what they should be doing. And we tried to define the extent to which they believed they could control their own hearing health, self efficacy.

The interventions involved developing some humorous 12-minute videos; I wish I had them on the computer for you to share. But anyways 12 minute videos are used to get them motivated, get them understanding. We have three different training videos for teaching them how to fit earplugs, earmuffs and canal caps. These are the banded ear protectors that fit just on the ear they have a little band that keep it in place, then hands-on demonstration, the last part of that is probably the most important. This is the model we'll talk through it just a moment.

We developed a partnership with the United Brotherhood of Carpenters. We collected their hearing threshold level, measured their exposures, assessed their safety culture, we analyzed the data and we developed the interventions and we fielded them. Then after we fielded them, we went back and we looked. We figured out what it was they were doing and how we could modify this then repeat the cycle. So for a carpenter, you do mortising, table saw, plainer, etc. The rule of thumb you can give if you have to plug it in, you really should be wearing your hearing protection. We have Niosh the power tool database of some power levels that are measured for whole number of tools, 170-some odd tools now in the loaded and unloaded conditions. Loaded condition is when they're actually cutting or grinding or drilling or whatever it might be. In the unloaded condition you just turn the thing on, you hang it in a chamber, you make measurements of the noise levels.

This is very typical of what we're seeing. Are these workers aware of this? Sure they are. 100% of them knew that they could lose their hearing as a result of their exposures.

Is it relevant to them? Well they don't know whether or not -- they know they're going to lose their hearing potentially, but don't know maybe how quickly. We had a 25-year-old group, the 35-year-old group, the 45-year-old group and 55-year-old group. This is just looking at the carpenters seeing what they're going to do in terms of having hearing loss over the course of their career. Is it relevant? Yes. They believe it was going to hurt their hearing by being exposed to loud noise. What can they do about it?

Well, let's take a look at how often they wore their protection while they were in noise: the carpenter safety trainers, the guys that are teaching them how to be safe, wore it 37% of the time? The carpenters who are supposed to be obeying, these are journeymen, apprentice carpenters that we're looking at, wore it 17% of the time.

The last group that we show here is the national hearing conservation association these are people like myself, like bill, like Sharon, who are involved in hearing and hearing conservation, 89% of the time.

Those persons who are aware of it, who believe that their ears are tools that they use for doing their research and some respects if you're in noise control consultant your ears are your tools. You have to preserve them and take care of them. So we're careful. Is it important?

Well, in the words of the late Rodney Dangerfield, I tell you, noise-induced hearing loss “don't get no respect.” We do have permission to use this from the Dangerfield estate. Is the problem important? If she says, yes, are you going to be able to hear it?

[ laughter ]

That happens to be Mark's son and his wife. Now, I had to laugh when Sharon showed this slide because I don't know whether we got it from the Tinnitus Association or whether the Tinnitus Association got it from Mark, but we've been using this slide for a long time with “I expected to lose my hearing but I thought it would be quiet. I never get a moment's peace and quiet, I have this constant ringing in my ears that does not go away.” It wasn't the fact that they were going to lose their hearing that motivated some of the carpenters; it was the fear of having tinnitus. The ringing in their ears.

Now, I have a neighbor who lives across the street from me, for a couple of years he was an apprentice carpenter, he came home one day and we were talking about things, he was telling me about his experience with using a pneumatic nail gun - how loud it was how he came home at night and his ears were just ringing and his head was pounding and I felt really, really bad. Because here I am one of the world's experts in hearing protection not protecting my neighbor and my friend. What did I do the next day? I went to my office, I bagged up a bunch of things that I have in different protectors that I could provide to him, came home gave them to him instructed him how to use them.

Can we do something about it?

Yes. We can remove the barriers, we can develop the self-efficacy. You can lead a horse to water but you can't make him drink. You can show a person how to use hearing protectors but you can't get them to wear them.

There are five barriers that we conveniently call the five Cs. If it isn't comfortable, somebody is not going to wear it. Of you hearing aid users, and cochlear implant users, if your molds don't fit what do you do? You go back to the audiologist you get them to be reshaped because if you don't, it hurts. I have a set of -- several sets of custom earplugs if they don't -- aren't comfortable I don't wear them. I have one pair that I wore just once and I've never really used it again, it's something that was made for me and I don't like it. If they aren't convenient, if you don't have them with you you're thought going to wear them. If they cost too much, these carpenters aren't going to spend \$150 on a pair of earplugs or would they? They will spend \$1250 on their scope or a thousand dollars on their rifle or whatever it might be; it has to be something that's important to them.

If they can't communicate they can't hear important sounds, they aren't going to use them. If they're dealing with pressure, peer pressure from their co-workers, such as my neighbor who when he went back the next day used the earplugs, was ridiculed by the other carpenters, the senior carpenters, they're not going to use them. We have to deal with barriers. Some of them are predictable. As I said, peer pressure. Some of the barriers are a little bit subtle.

I said I would come back to this protector. One of the early studies that we did a field studies with carpenters in the St. Louis area, back in '95 mark and Carol, Carol is Mark's wife. They were out doing the measurements of hearing protection and they were testing these green earplugs that you see there. They called me up and said, "Bill, can we cut the amount of time for the fit testing, which frequencies can we throw away and get to the good answer?" I said, "why?" "Well, the foreman, the manager said we can do the fit testing but the foreman won't let us do the fit testing because it takes too long." I did my math. I worked out which frequencies they could do. But the answer to it was to change the color of the earplugs. Because now if they're using red, white and blue earplugs, it is patriotic.

You can sneak around the barrier. They have also done some work with the coal miners and trainers at the mine safety institutes in Berkeley, West Virginia, I believe it is. Comfort, communication, convenience, bottom one says roof "talk" we've heard about various mines that have been in the news over the last few years where they have had collapses. Roof talk - what you hear just before the roof falls in on you. If you hear it, you move.

Sharon and Bill have probably used the mannequin, we had one of those in our Pittsburgh group - they took it down into a mine to do measurements of the dust monitor, personal dust monitor well, mannequin didn't move out of the way when the roof fell in, very expensive mannequin. Dealing with these perceptions of people with regards to using protection is extremely important. Can we do something about it?

Again I mentioned that we have tailored video clips that we developed, we had subjective tests that we tried to help them to be able to use to figure out whether the protection is properly seeded, whether it's working well. So, does the touchy-feely stuff work? Yes. It does. Here are the results.

When we look at the barriers and comfort about 50% of the persons pre-intervention thought that earplugs could be comfortable -- didn't think that earplugs would be comfortable if they were fit correctly. Post intervention, over 80% agreed with or strongly agreed with that.

Do they muffle important sounds? Are they going to be able to hear the warning sounds? Most of them disagreed that -- I'm sorry. Most of them agreed that it would be hard to hear the warning sounds and things like back-up sounds. But after the intervention we were able to demonstrate to them that, yes, you could. So almost 75-77% disagreed with that statement. That's a positive result. Barriers to communication.

Will they be able to understand speech while doing their job and being protected. Most of them would have thought that they couldn't, after the intervention, they were able to or believe that they could. If they had protection, would they use it when they're around noise? And this is the one I like because it shows that most of them were making an intention to do this. That's the important part, if you aren't going to do something about it, the battle is lost.

Here is just a simple bit of evidence from the Air Force study, we went up and just simply changed the protectors that they were using from -- amount used went from one-third to two-third in the amount of time. Self-efficacy this is another one I like out of this.

When you ask somebody whether they can teach you how to do something, then you have a sensor if you feel that you're able to teach others about doing something then you have confidence in your own ability to do. This 90%, 92% agreed with it after the intervention. So, what affect does training have?

Here's two products that were advertised with a 29 and 27 noise reduction rating, just averaged them together to get 28. We brought 100 persons, these are college educated students at Michigan state, brought them in, tested them with fit testing system and their average performance was 6 decibels. That's abysmally low. When we tested them after giving them one-on-one training, their attenuation values became 21 db. This is a group performance value.

If we tested them in two to a group, three to a group, they were required to show the experimenter that they could do this and demonstrate these things, again, 17 db.

What does this translate to in the amount of time as Dr. Clark alluded to, how loud and how long you are exposed to it. What does this amount to? It means that you can work in that noise four times as long. What's on the radar?

Well, I mentioned I do a lot of work in hearing protection and I'm going to skip through some of this just to get down to the bottom. We have history of different standards for testing hearing protection attenuation. We have a number of standards in the European union that are similar to new standards in the United States. The bottom one down there is the new standard in the United States, 2007, to rate the performance of hearing protection devices.

In 2009 the EPA, Environmental Protection Agency, proposed new labeling rules.

What you might be seeing, I'm hoping you'll see in the next several years maybe within my lifetime if I'm fortunate, is something that might look like this.

You see a bar on this, to the left of the bar you see -- left of the black bar you see 18 decibels to the right you see 32 decibels. What those represent, lower number represents the protection performance that would be achieved by 80% of the persons in the test panel. The number to the right of that bar represents the protection performance received by 20% of the protection panel.

If you can imagine now that bell curve of attenuation, is that the test panel received were describing the limits of that bell curve. How are we going to use these kinds of values? Suppose worker is exposed to 9 decibels of noise, what kind of exposures might they get if we look at these values. Well, 80% of the workers would see 97 minus 18. We'd end up with 79 db of exposure.

20% of the workers, leaving us with 65 decibels of exposure.

So workers, if they're wearing this product as it should be worn, would be protected between 65-79 decibels of noise exposure.

That's below these limits that we set with Niosh and OSHA and Msha and EPA in terms of the annual or daily exposure limits for a worker.

Now, this animation here is an example, said in the program that I was going to be working on impulse noise. I am, I am doing quite a bit of work on impulse noise.

This is an example of study that the Army conducted in the early 1990s looking at the performance and risks of their service members being exposed to weapons noise. And we have developed this Ansi S12.42 method for looking for performance of protectors.

There are devices, if you recall they're not your father's hearing protectors. Earplugs and earmuffs that are level -- normal conversational levels, you're able to communicate. We did not have methods up until two years ago of how to do this kind of a measurement how to rate the performance of these types of protectors. And the EPA is going to put these in to place hopefully we'll see something new in the market.

There are now systems that are available that will teach and help test a worker.

If you recall I mentioned they called me from St. Louis, this is Carol, this is a carpenter being tested. This is the system that we were able to use to do their testing.

Why do we want to test people's hearing and hearing protection? Because we want to know what it is that the employees are able to use. We can help them choose protectors that fit. We want to educate them. The opportunity for workers who are in a hearing conservation program every year they're supposed to have an annual audiogram.

It gives us an opportunity to educate them and to talk to them and teach them.

We want to protect the workers, as I say as an employer, you want to cover your "assets."

If you don't cover them, you're going to be faced with worker's compensation issues.

You want to fit test the worker because we want to make sure that they have sufficient protection for their specific jobs. And there are some jobs that are extraordinary - now see people who are working on the decks of aircraft carriers, people who are working in sand blasting, law enforcement personnel.

What we need to do that's going to be appropriate to test them and provide them adequate and accurate assessment of their protection? Well, in the early '76 Niosh funded a study - he developed an earmuff with a speaker. And a whole bunch of equipment.

This fits inside of probably something about the size of this stage that we're dealing with. Just racks of equipment necessary to generate the signals and to make the measurements and such. Now we have in 2011, we have all these different systems, microphones that can take measurement outside and inside the hearing protector, different systems that replicate what we do in the laboratory.

Other types of things such as smart hearing protection that make measurements.

Here are two of the different systems, Phonak is here at the conference, I have stopped in talked to them yesterday. They didn't have their safety meter system there, ear fit, yellow foam ear plug. People if you look at this on the temple of the eye piece there you'll see that there's a little gadget, that's a microphone and if you can see it more closely there's a probe tube that goes in to the ear plug and makes measurement underneath the ear plug inside next to the -- close to the ear drum. You make a measurement outside and inside, get the difference between those. There are all these other systems now.

NIOSH developed a couple of these, other commercial systems that are available, working on replicating the laboratory systems. Honeywell, the Veripro system loudness balance approach and there's the Dosimete - it's measuring your noise exposure in the ear canal if you're wearing your plugs, otherwise it's measuring noise exposure that you're getting. There's some issues with the accuracy about how it

does that, just very technical things, but it's giving you a measure of what kind of exposure you are receiving.

We have questions then of how do we compare the ratings that these things. Some of them give us attenuation rating or a dose, some of them give us pass-fail. These are just the ones that give personal attenuation ratings, every one of them gives a different rating, we're in the process now of developing a standard to bring uniformity to the different fit test systems.

So, can we develop improved methods to aid the selection of hearing protection for hearing impaired workers? You bet we can. But we need to have management support, if we don't have the managers' support, as it says, a fish rots from the head down, we can't motivate them, can't get people that are in charge of the safety and health to be involved in it, we're not going to make progress.

Thank you.

[ Applause ]

>> We have a few moments for specific questions to Dr. Murphy.

Then we'll open up to general discussion.

>> I'm a teacher in the public schools in New York City.

I work in the Bronx and sometimes I go to concerts, festivals where the music is so loud, it's terrible. They jack it up really loud. I go to the principals and I give them articles in the "New York Times"; they're totally uneducated on this. Even though they're the principal of the school and they allow this to happen. You mentioned about videos, when I give a workshop on hearing loss for teachers and administrators besides me passing out articles on this, is there any two-minute video something I can show them to get the point across to make them think, oh, maybe I should turn down the sound for these concerts?

>> I'm going to look at my colleague --

>> I have one more question.

>> Yes, there is. I was thinking "turn it to the left."

>> You'll find online there are a number of sources of educational materials that you can, for example, you can even use them in the classroom. But you could share them with other professionals who are managing educational settings. Some have pulled together some videos, some use educational rap to get the message across.

I was involved in one project where we put out a rap song called "turn it to the left" and it basically educates people about the dangers of having things like personal stereo systems turned up too high. There are really fun materials. If you'd like, we can share some of those websites with you.

I know NIOSH has a great deal of educational material online where you can look at those are great teaching tools if you want that information I don't know all the websites off the top of my head but the American Academy of Audiology, the American Speech-Language-Hearing Association. The National Institutes of Health have special places on their websites where they deal with noise conservation education. And NIOSH as well.

>> Especially if you go and look out here in the vendors, I'm assuming they're still going to be here today. We have NIDCD they have campaign for -- it's a noisy world.

There's also ASHA which has an ear buds campaign, "Listen to your buds."

>> NIOSH, I don't have a website there but [www.cdc.gov](http://www.cdc.gov).

And hopefully going live, the National Hearing Conservation Association has section on educational materials for classrooms, for example. Their website is [hearingconservation.org](http://hearingconservation.org) and [acousticalsociety.org](http://acousticalsociety.org) - they have new effort. Hopefully that can help.

You can use my e-mail down there and contact me I'd be happy to try to help you out.

>> I have another question.

It's funny because I'm the one who is deaf but when I talk to the principals they have a deaf ear listening to me. [ laughter ]

The other question I have is, my hearing loss is genetic; my son who is 26 is losing his hearing. I told him when he was younger he started at 19, to wear earplugs. He didn't listen to me. Now he listens to me said, "mom, you were right. I should have worn earplugs."

The question is, are there any studies on genetic issues on noise that if you have genetic predisposition to hearing loss you will go deaf faster with loud music?

>> The question of whether our genetic susceptibilities to hearing loss might influence our genetic susceptibilities to things like noise exposure or exposure to ototoxic drugs, is really getting a lot of attention now in laboratories throughout the country.

There's a laboratory where Dr. Clark works that is looking at mouse models of this and reason that a lot of us use mice for these studies is because we can completely control their genetic background and address the one question that we want to ask is, is this particular genetic background making this mouse more susceptible to noise or less susceptible to noise.

I'm involved in a grant-funded study that does the same thing. We have a strain of highs that if we put that mouse in the same cage with another mouse and we expose them identically there is a huge difference. So the brief answer to your question is, it's almost certainly the case that there are genetic underpinnings to human susceptibility to noise, we don't have all the answers.

I can't tell you today that if you have this gene you will be more susceptible. But I can tell you that many people are working on that and certainly we know some of the genes in mice and it's likely that those genes will be found in humans as well.

>> To just amplify the answer on the basis of what we know, we can't really say that that particular genetic history that your son has would make him more susceptible to noise-induced hearing loss, there's so many inter-actions. We have to keep in mind the negative statement, the things that we can't say.

Certainly a possibility but I know of no evidence that suggests that for example child who has connection on 26 mutation which is very common mutation is more susceptible to noise.

>> Your presentation focused a lot on people that don't currently wear assistive devices I'm curious to find out for someone who is wearing a hearing aid now, is exposed to these different situations how

does that work. I work on a flightline on occasion and with the hearing aid I don't really -- can't put in any earplugs I'm curious on how you address that with the population that's out there already.

>> We have done a study, I want to say about 2001 or 2002 where we were looking at that question which is, how much hearing protection can we put on a person who is wearing hearing aids. And I know that the papers are in process of a dissertation, the apps is, if we use 85 decibels as a limit for their noise exposure for a workers exposure, really what that translates to is about 3% risk of developing hearing loss if you're working in that noise eight hours a day, five days a week, 40 years, that's from the analysis that we've done with work at NIOSH.

If we use 85 decibels as the limit, then you can combine the attenuation of the hearing protection with the amplification of the hearing aid and be able to make an estimate of whether or not their noise exposure to above or below that limit. And if it's above that limit then we change how we look at it and how we recommend what someone might receive.

But as practical matter, if workers are working in environments where the noise level is 90 or 95 decibels they require hearing protection to reduce the exposure to a safe level, in that case the hearing aid is not going to be much of a benefit anyway.

Many employers will recommend that the person not wear the hearing aid while they're wearing hearing protection. So it's a dicey issue. I think there are many industrial hearing conservation programs where they recommend that you not wear your hearing aid when you're in any environment.

>> There's another element, too. Which would be for workers who are maybe in an intermittent - you he mentioned a flight line. Should you probably consider having electronic device which amplifies sound when you're not around the airplanes and it will then shut off and reduce the amount of sound restoration that it provides when the noise is present? So for intermittent environment something that has amplification that is sensitive to those external sound levels that can adjust it appropriately. That may help you get over the hearing impairment that you suffer.

>> A few weeks ago, this is primarily to the third speaker on labeling, but a few weeks ago I was shopping for hearing muffs because I wanted them both for myself and my grandson when we mow a lawn together. And I found absolutely nothing, no kind of measurement whatsoever; first of all I didn't know what measurement I was looking for but I found nothing on measurement. I wonder what would you recommend in looking for earmuffs.

>> As far as using earmuffs, I would have actually said you are probably using the right thing. My son and I we have earmuffs that we just hang over the steering wheel or the handle of the lawnmower so they're always there. And we use them when we mow. They give typically 15, 25 decibels of noise reduction. Typical lawnmower is going to be around 95 decibels.

So in order to reduce it for that short period of time that you are using it you should have adequate protection with something like that.

>> I've often seen singers on stage using ear protective devices against heavy metal beats. How much protection against hearing damages do they offer?

>> Interesting.

The folks you're talking about are sound restoration systems or the personal audio systems, probably our sound guys over here would have sense of what kind of levels they're being exposed to. Those devices, in fact I have some in my briefcase, those devices can provide 29, 30 decibels of noise reduction. However, when persons are listening to those, there was study that was in International Journal of Audiology in 2008, and the levels that they found were almost the same as the levels if they didn't wear them and they were listening to the self reinforcement, the sound reinforcement on stage, the monitors that they had. That level was around 106 decibels. It was research study that was done at Vanderbilt; I think it's vital. I forget the name of the researcher that did it.

The levels that they were being exposed to were really quite high. It didn't change much when they were wearing their personal monitors versus not wearing those.

>> Over here, question.

>> Thank you.

>> Hearing loss is age related.

Is it possible that what is age related is really a result of long exposure to noise, I guess my question is, whether in the research that's being done do you factor for age?

>> Yes.

I'll take the first answer to that, in fact Dr. Gates would have talked about that exact issue if I were able to be here today. There's no question that hearing sensitivity declines with age.

That's called presbycusis. Which is "old hearing," there are many components to that.

And one of the components is the natural aging process itself, but the sore point is what you do to your ears as you age. Hearing loss that accumulates over a lifetime is the addition of the affects due to the aging process itself, plus your exposure to noise in the workplace, plus going out to noisy disco, maybe smoking, poor health habits, nutrition.

They are in combination. When you think about the hearing levels of somebody who is 50 years of age, who works in now noisy occupation, for example, it is important to keep in mind that some of that hearing loss that you might see in that individual is related to occupational noise.

Possibly but also there's another component that's related to aging. The best study in Dr. Gates would have shown you these data is study of individuals from Chile who moved to -- who moved over to civilization they were born in an environment where there was not any occupational noise, really wasn't any noise exposure at all. They were on Easter Island, then they moved to Chile and got jobs in industry. Clear difference between people who stayed on the island and went to civilization for ten years.

They were genetically the same. They were all related to each other yet difference in hearing sensitivity was significant. So there is -- there's the aging part and itself and noise part that adds to it. The susceptibility issues that Dr. Kujawa mentioned.

Are very complicated it's hard to figure out exactly how the two add up but they do add.

>> I would like to share a little success story on the subject of the motivation for using the hearing protection. I had five teenagers at one time. At the period of time when rock concerts were first going outdoors, and I beat upon them that this rock music stuff needed hearing protection, I worked in noise control in a Naval shipyard I was convinced.

I finally convinced one of them to wear hearing protection at a rock concert telling him that it would allow him to hear what he was really interested in better because it wouldn't be masked by the trash noise. And he reluctantly took a pair of hearing protectors and went to the rock concert.

It worked so well that at the next rock concert, the other kids were asking me for hearing protection and extras to push off on their friends. This last weekend, I think it's -- hearing protection is genetic as well.

This last weekend I witnessed my grandson on riding lawnmower with earmuffs.

So, the argument that the hearing protection protects you from noise, you don't want to hear and allows noise that you do want to hear turned out to be very powerful for the kids. Might help somebody.

>> That's interesting.

Number of years ago we had a band come and give a concert at our church for the morning service. And I commented to the engineer, the sound engineer I said, you know, we have older persons in our church that really don't like it that loud.

He says, that's okay, I'll start it soft and then we'll get louder because then they will get used to it. That's called temporary threshold shift.

>> Over here.

>> I have somewhat related question. I have pretty normal hearing but significant tinnitus but I find -- I don't go to rock concerts, but I do go to dance performances and other musical events. And movies. And I find very consistently that the sound level that seems just right to the sound technician is well above my comfort level. I have two questions. One, am I wise to wear ear protection in those situations? And, two, has there been -- the data on the teenagers wouldn't seem to support this, but has there been a cultural or generational shift toward louder music in non-rock situations?

Do sound technicians do things differently than they might have done in the past?

>> You're the recreational exposure guy. A couple of issues, one is relating to the hearing and the symptoms that you just mentioned. We didn't talk about it today at all but there's another symptom that relates to noise exposure and also to the presence of tip nights, that is the condition called hyperacusis. Hyperacusis, they believe it is as important if not more important in terms of the symptoms that bother individuals.

So if you have tinnitus and you also are sensitive to loud sounds you may be someone who is exhibiting hyperacusis, is that is abnormal sensitivity to loud sounds.

The other thing in terms of the question about whether the engineers have changed the sound levels, I think there's not a lot of data to answer that question. Just anecdotally, I don't think that the sound

engineers are making concerts louder than they were ten years or 20 years ago. I think actually they may be making highest level of sound higher -- lower than they did ten or 20 years ago.

But there's not been evidence of a lot of difference, the challenge with real rock concerts where you have a lot of people there is, much of the noise is not just from the concert but from the people screaming and cheering around it and it relates to the size of the arena and what kind ever acoustics are in the arena.

Most of the rock concerts that are -- that I've measured have had average levels of between about 92 and 102 db A-weighted level. Those are all very loud. But I've done some recently and some 20 years ago they seem to be about the same.

>> There are also elements that you can bring in as a community where you are putting in regulations or outdoor arenas and annoyance to the community around you.

Having noise limits where in fact if they're measuring above the particular level, the electronics get shut off for the concert.

>> New York City has an ordinance like that.

>> Right. New York City has the department of environmental protection has an order answer for construction noise. I don't know that that's going to help too much.

But then there are also other communities out there now that have ordinances for noise rating out to the community.

>> Over here.

>> I have a question for Dr. Clark, please.

Dr. Clark, you were citing a national survey that was done in 2005-2006 that was giving the demography of children ages zero to 19 who reported hearing loss. And you said that the majority of children zero to 19 reporting a hearing loss reported that it was unilateral and you went on to say that this is not characteristic of noise-induced hearing loss. So, my question is, what causes unilateral hearing loss?

>> That's a really great question.

First of all, are two issues. The issue that I mentioned, it's a little bit technical but the reason that I believe that the majority of the hearing loss was reported in children it was age 6-19, it wasn't birth -- the tests were from school-age children 6-19. But the reason I believe that so many of the losses were unilateral is that we know from all national surveys both here in the United States and other countries there are couple of things that you can say about hearing levels of people. Number one, is boys tend to be just a little bit worse than girls. Young boys and older men, hearing level of males is usually worse than hearing levels of females. We think that much of that has to do with different listening habits, men just get more noise exposure in their jobs, et cetera. But there may be other factors as well. But then second factor is that in two-thirds of the cases the left ear is slightly worse than the right ear. The right ear seems to be rattle bit more sensitive than the left -- to be a little bit more sensitive than the left year, I don't know if there have been a good explanation, the hemisphere Rick advantage of brain for perceiving speech maybe the right ear is tuned for speech the left ear is tuned for noise.

I don't think anybody has ever really identified why that is.

Certainly shooters, people who shoot long rifles right-handed shooters put the gun on the right shoulder and left ear gets more noise exposure so in older males, where there's a lot of shooting you see the left ear a little bit different. Whatever the real cause is, I think what happens is, in this little case study method where they look at when the thresholds just get worse to find a case, end up having individuals who are individuals who have a hearing in their left ear just a little bit worse than the right ear, being called a unilateral case. When they really aren't. There's just a couple of decibels of difference between.

Then second answer is, what does cause unilateral hearing loss and infectious, disease, then in adults very commonly -- neuromas and sudden sensory neural hearing loss where hearing goes away just sometimes without any known cause often tends to be unilateral. Are there other factors we should mention?

>> Mumps.

>> Thank you.

>> Hello, Doctor.

My name is Bob Foster from St. Louis, Missouri.

I think you've covered some of this but I have a friend who was in Vietnam and exposed to a lot of noise and it's come back and he doesn't have hearing loss, but he has a maddening case of tinnitus. And he blames it on the noise that he was exposed to.

And I was wondering if that's a possibility?

>> Well, it certainly is a possibility.

If you say he doesn't have hearing loss does that mean that he has seen an audiologist and had his hearing tested?

>> Yes. Several times. And he's even come to HLAA meeting when we had somebody that talked about tinnitus.

>> Well, one of the things to keep in mind, I think Dr. Kujawa can also address this, is that more and more we used to think that tinnitus always happened in periphery, somehow related to damage to those hair cells. But it's getting to be better accepted that it really is a central phenomenon. And that it happens up in the brain it may have to do with the delicate balance between the nerve input that comes in to the brain and nerve output that goes back out to essentially control the mechanism. I have to tell you that I have high frequency sensorineural hearing loss. I suffer from tinnitus but I only notice if I start talking about it. About 30 seconds ago my ears just took off.

And now all I really hear is a high pitched sound in both ears because we're talking about tinnitus.

When I go away, I quit thinking about it and it will go away.

There is a central component what I'm thinking is, think about the studies that Dr. Kujawa talked about where the ear recovers completely, the hearing sensitivity recovers but the nerve input going in to the central nervous system is now impaired. If the nerve input that comes out is like a control mechanism. If the nerves that come back out from the brain to the ear are not in balance, they actually inhibit the -- I'm getting too complicated.

If you mess up one side of the system you may get it to go in to oscillation.

And that could create the perception of tinnitus so, I think it's not unheard of, that's a funny term, unheard that have tinnitus could be related to neural degeneration that didn't actually have profound or severe hearing loss associated with it. That's an important issue, the guy is valid. We just don't know how to evaluate that.

>> Thank you.

I have a question that probably applies to majority of the people here today, that's the fact that both noise exposure on a passenger or commercial airlines recommendation perhaps could protect ourselves. There are studies on noise exposures on commercial aircraft and the old 727s were really noisy. But the newer technology, the MD80s most of the planes that you fly on in the very back of the plane, ones that have two engines on the very back so rear seats are a little noisier than the mid seats on them. But those levels to the best of my knowledge are around 80 decibels or so, or 82 decibels.

Certainly I think that these little foam earplugs really serve nice purpose because they do provide enough attenuation that would recommend that you use them. There's another advantage that I never thought about, but I have colleague who is active in hearing conservation, she always wears hearing protectors on the airplane. That's good protecting your hearing against loud noise. Good to see do you that practice.

She said, that's not the reason I wear the hearing protection. She's kind of attractive; she said it keeps away men who are trying to pick me up for a drink afterward. Or somebody who wants to tell me their life story about their grandchildren. So I just put them in and it serves a message that we do social isolation here - that I get to travel by myself on an airplane.

That is -- very interesting I'm going to add one more comment not related but kind of. There's been recent study, I think it's Brian Fligar the group at Harvard who have looked at why kids wear iPods when they're riding on the subway when they're in very urban areas. One of the major reasons is, the social aspects that they -- isolation that they can acquire by putting their headphones on. Nobody bothers you. When you live in a rural environment it's very easy to be by yourself. But when you live in New York City go to NYU, take the subway - it's pretty hard to be by yourself.

One way to get to be by yourself - put your ear phones on and listen to your iPod while you're traveling. I think there's some of that in it as well.

>> Thank you.

We're going to wrap up. I want to express our thanks to the Deafness Research Foundation, for inviting us to give this talk, your questions have been fascinating and made our trip worthwhile. So thanks very much for all your input.

[ Applause ]

>> Thank you for supporting this really fascinating discussion today. Thank you very much.

