

# CDC PUBLIC HEALTH GRAND ROUNDS

## It's Loud Out There: Hearing Health across the Lifespan



Accessible version: [https://youtu.be/B7XOx4j\\_rf0](https://youtu.be/B7XOx4j_rf0)

June 20, 2017



U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention

# Hearing Loss: Poorly Recognized but Often Preventable



**John Eichwald, MA**

*Lead Health Scientist, Office of Science*  
National Center for Environmental Health



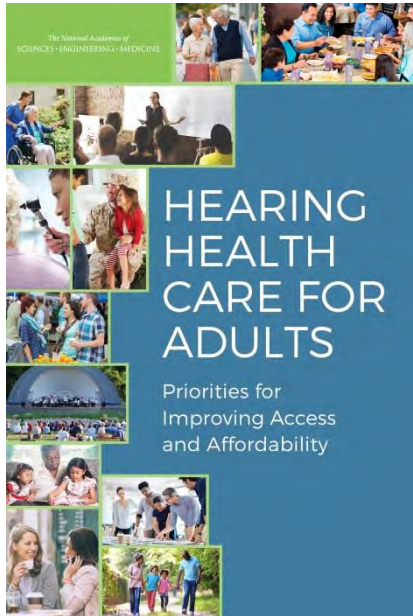


# Hearing Health Care for Adults

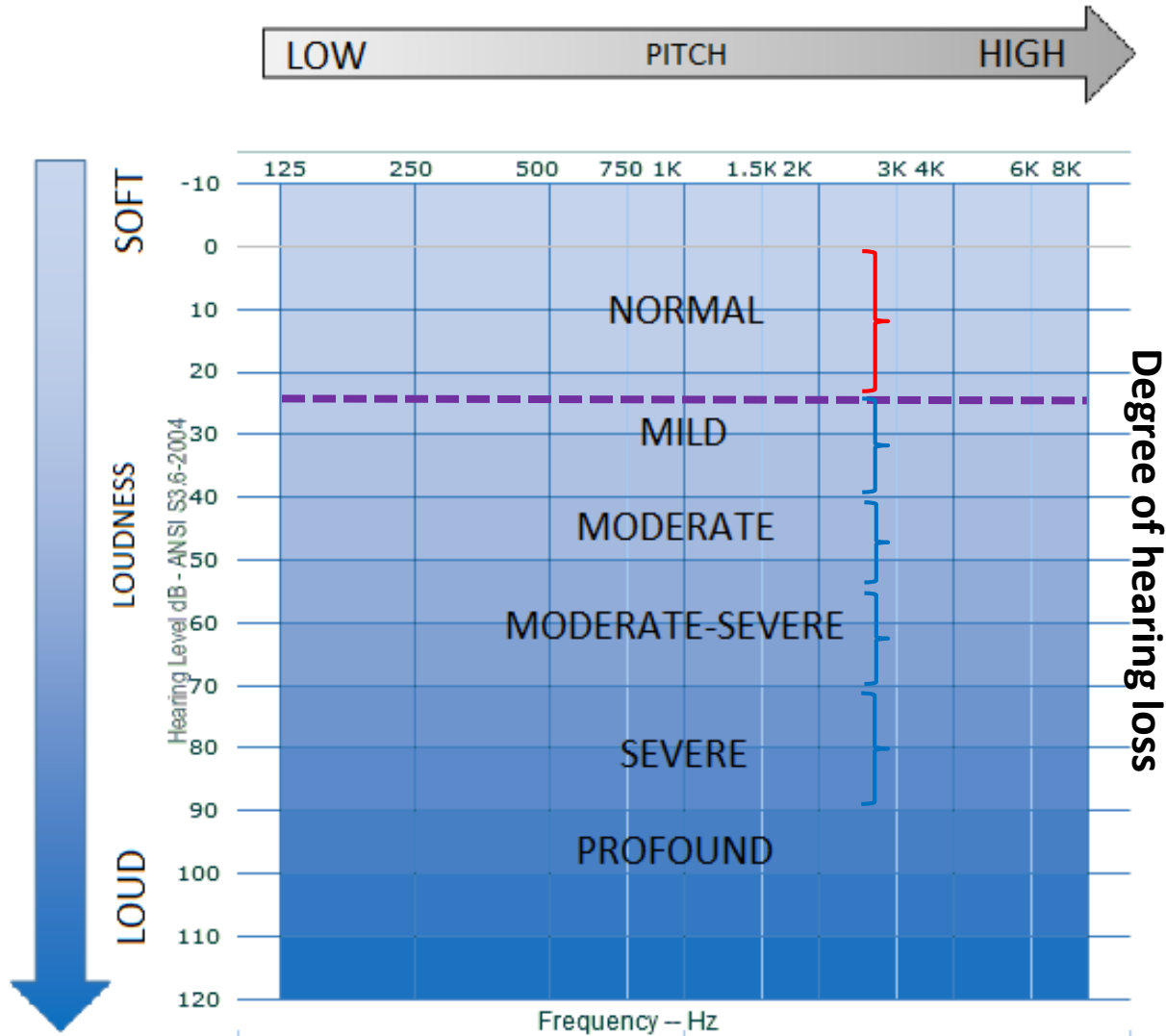
## Priorities for Improving Access and Affordability

### Recommendations for CDC and other partners

- **Strengthen efforts to collect, analyze, and share data on adult hearing loss and the effects of hearing loss and its treatment on patient outcomes**
- **Promote hearing health in regular medical visits**
- **Improve public information on hearing health and hearing-related technologies and services, and promote public awareness about hearing and hearing health care**



# Audiometric Measurement of Hearing Loss (Adults)



**Pitch,  
or frequency,  
is measured  
in Hertz (Hz)**

**Loudness, or  
sound intensity,  
is measured  
in decibels (dB)**

# Simulation of Hearing Loss: Normal Hearing

## ➤ Normal Hearing



***“When the sunlight strikes raindrops in the air, they act as a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors.”***

# Simulation of Hearing Loss: Mild Hearing Loss

## ➤ Mild Hearing Loss



*“When the -unlight –trike- raindrop- in the air, they act as a pri-m and form a rainbow. The rainbow is a division of whi-- ligh- into many beautiful colors.”*

# Simulation of Hearing Loss: Moderate Hearing Loss

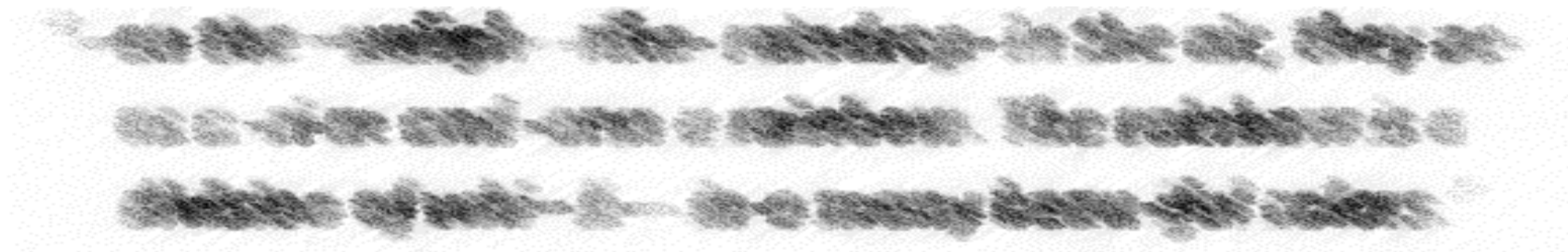
## ➤ Moderate Hearing Loss



*“-en the -unligh- -rike- raindrop- in the air, they ac-  
as a -ri-m and -orm a rainbow. The rainbow is a  
division of whi- li-- in-o many beau-iful colors.”*

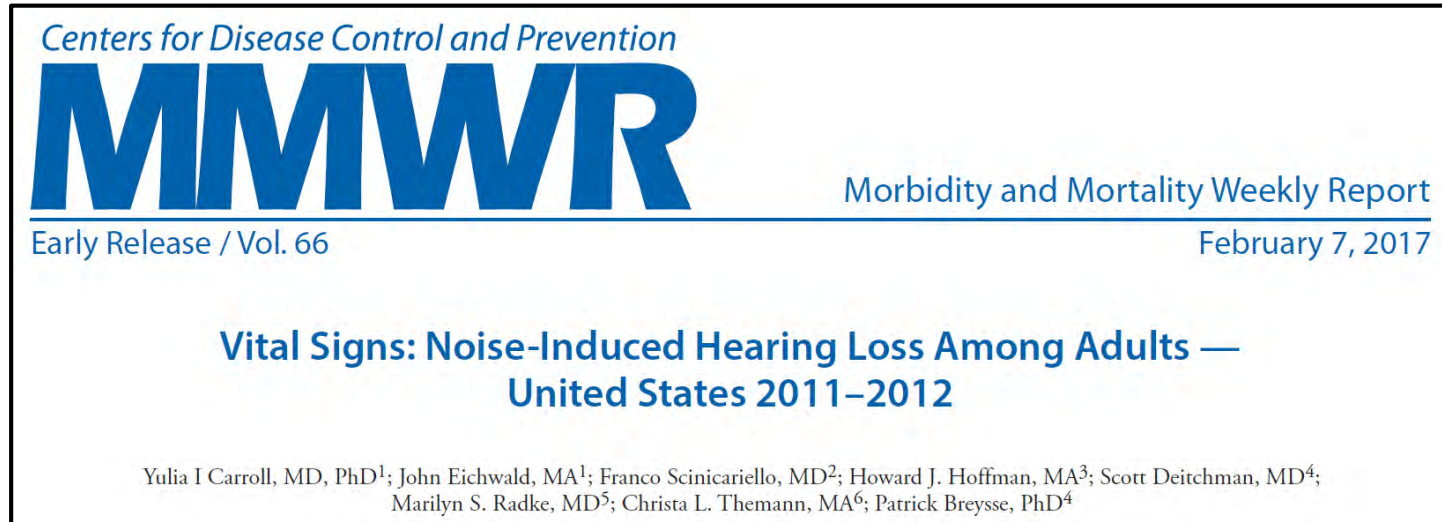
# Simulation of Hearing Loss: Moderate Hearing Loss With Noise

## ➤ Moderate Hearing Loss in Noise





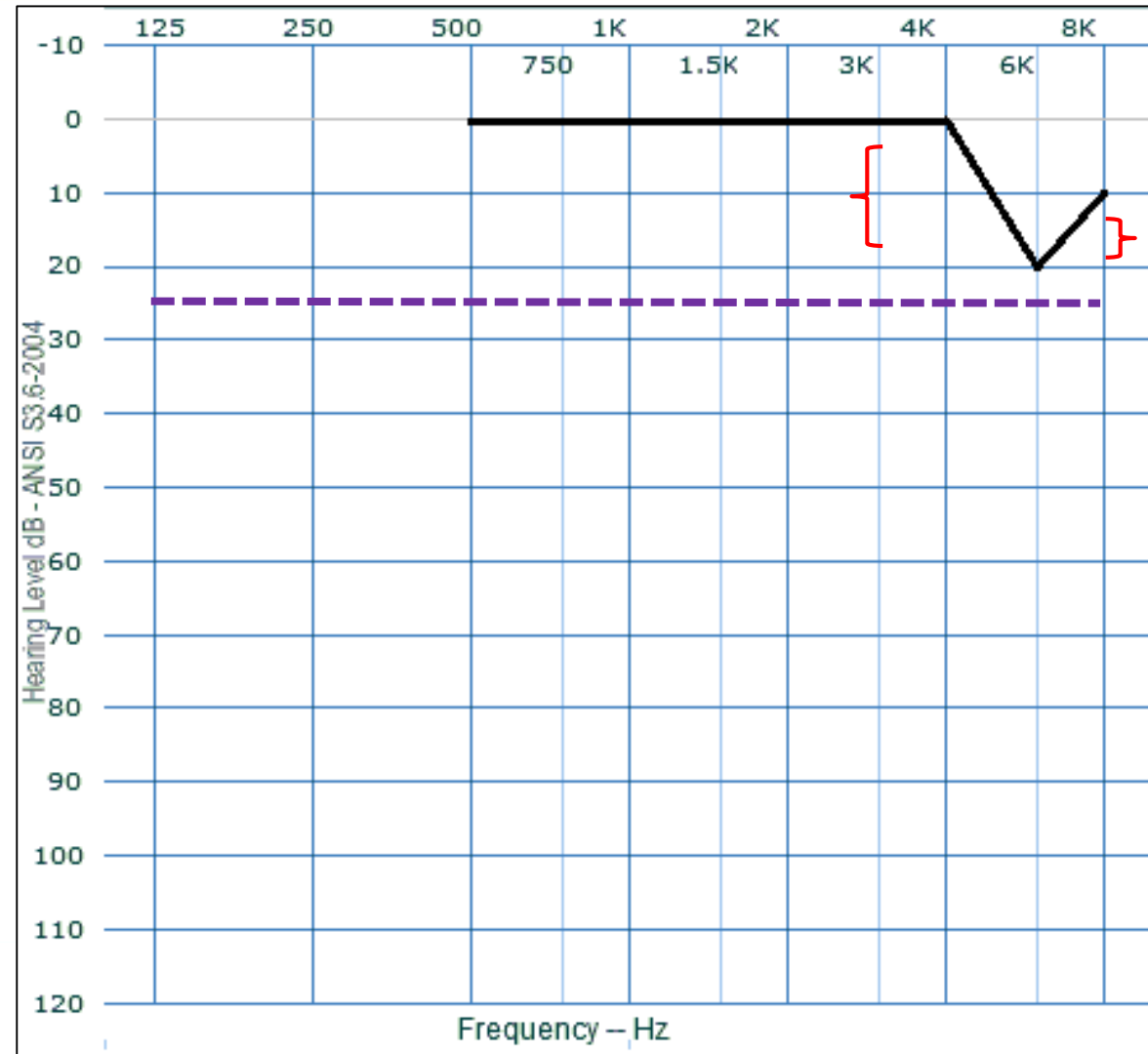
# Noise-Induced Hearing Loss Among Adults



- **Includes a media release, fact sheet, website content, a town hall webinar and multiple social media tools**
  - Most provided in English and Spanish

# Noise-Induced High-frequency Audiometric Notch

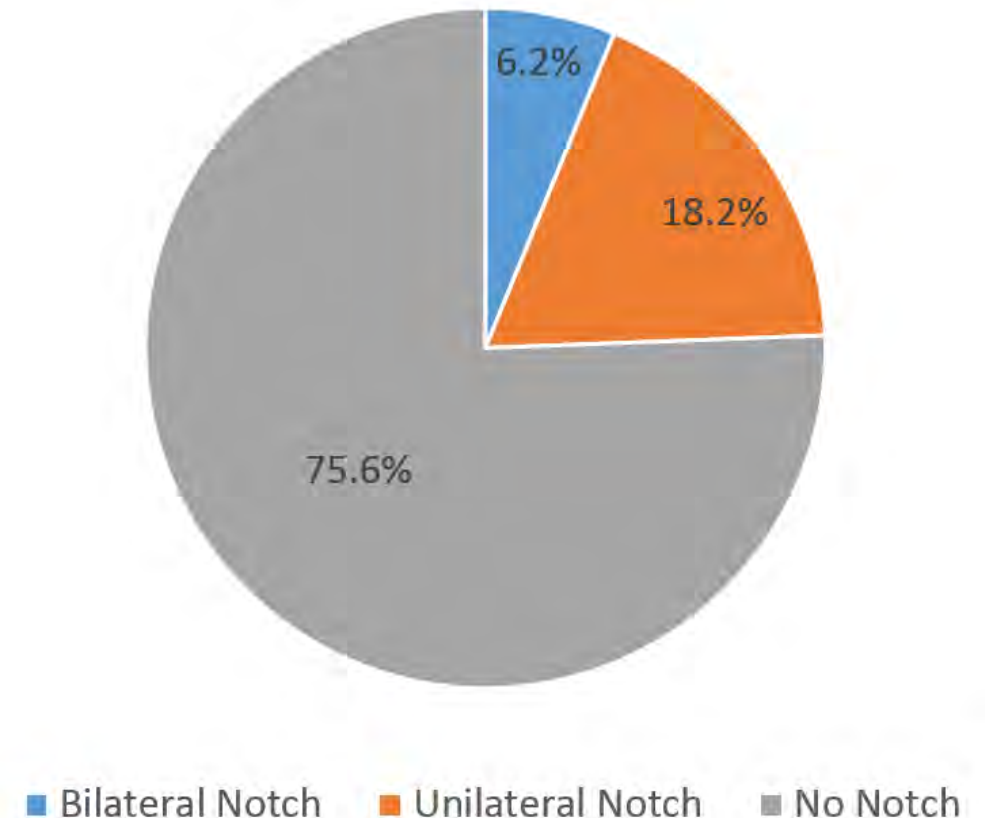
- **Audiometric notch suggests hearing damage from exposure to loud noise levels**
- **Defined as**
  - Any threshold at 3, 4, or 6 kHz that exceeds the average threshold in the frequencies, 500 Hz and 1 kHz by **15 dB HL** and the threshold at 8 kHz is at least **5 dB HL** better (lower) than the maximum threshold at 3, 4, or 6 kHz



# 1 in 4 US Adults Have Evidence of Noise-Induced Hearing Loss

- **24% or 39.4 million U.S. adults**
- **3/4 of hearing loss is one-sided (unilateral)**

Audiometric Notch  
(n = 3,583)



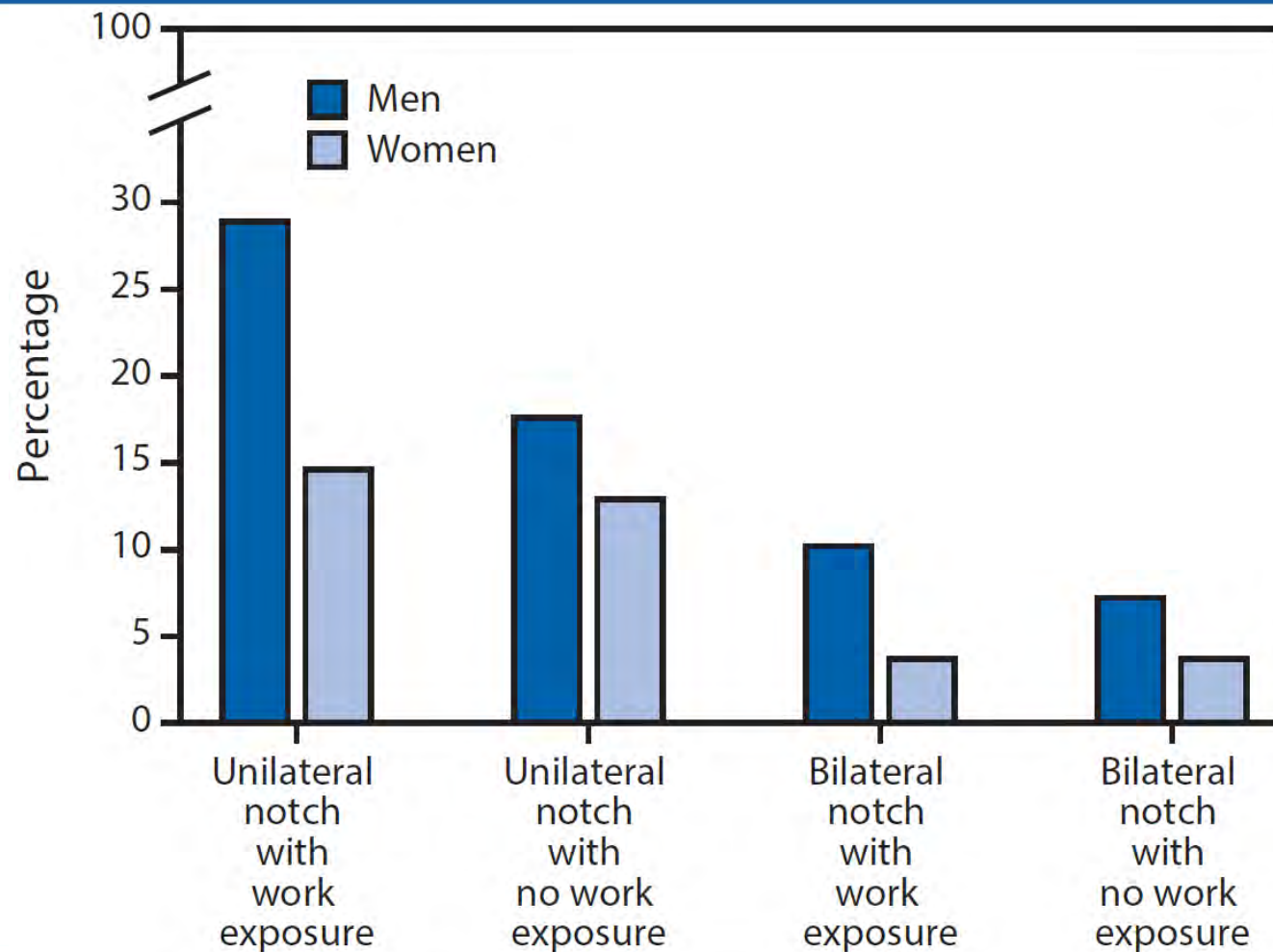
# 1 in 5 with Audiometric Notch Report No Exposure to Noise at Work

## ➤ 33% reported exposure to noise at work

- Twice as likely to have audiometric notch

## ➤ 20% reported *no* exposure to noise at work

- Males = 25%
- Females = 17%



# Loud Sounds At Home or In Community Cause Hearing Damage

- **21 million adults in the U.S. likely have hearing damage from loud sound sources at home or in their communities**
- **Noise sources include power tools, recreational vehicles, and listening to music more than 10 hours per week**





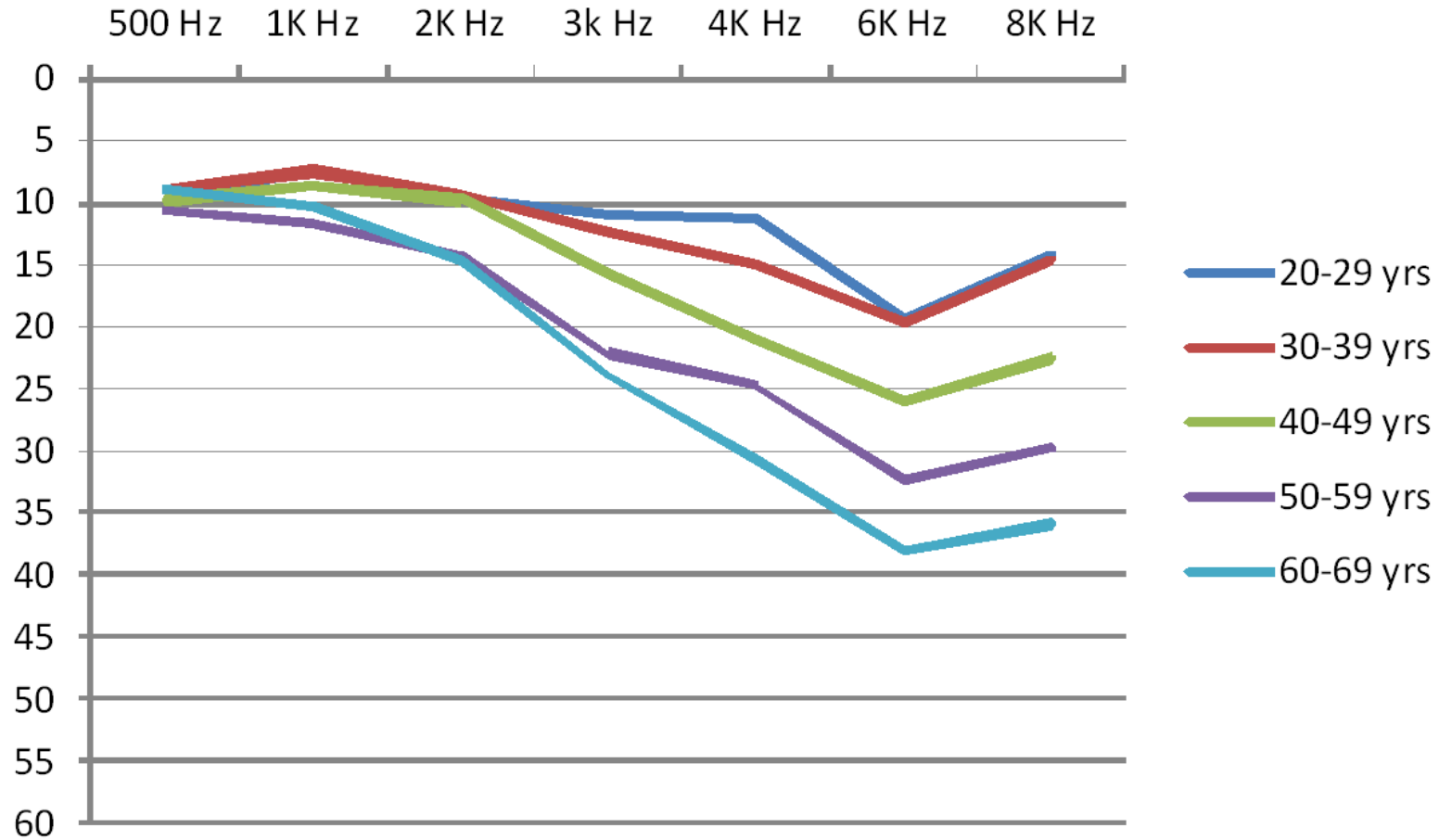
# Damage Accumulates Over Time



## ➤ Presence of notch in one or both ears:

- Age 20–29 years = **19%**
- Age 30–39 years = **25%**
- Age 40–49 years = **29%**
- Age 50–59 years = **27%**
- Age 60–69 years = **21%**

# Damage Accumulates Over a Lifetime



Unilateral Notch, Males and Females (Left Ear)

# Unrecognized Hearing Loss Occurs Frequently

- **People with auditory damage caused by noise frequently do not recognize it**
- **One in four people who reported “excellent” or “good” hearing had an audiometric notch**
- **70% of adults exposed to loud noise in the past 12 months never or seldom wore hearing protection**



# Prevention of Hearing Loss

- **Move away or shorten the exposure time**
  - Avoid loud sound sources (e.g., loudspeakers)
- **Turn the volume down**
  - Reduce listening time as well
- **Wear hearing protection**
  - Needs to fit well to effectively reduce exposure



# Health Providers Can Help Detect and Prevent Hearing Loss

- **Ask about hearing and noise exposures**
- **Examine hearing during regular medical and wellness visits**
- **Refer for hearing evaluation and treatment**





# Child and Adolescent Hearing Health



**Deanna K. Meinke, PhD, CCC-A**

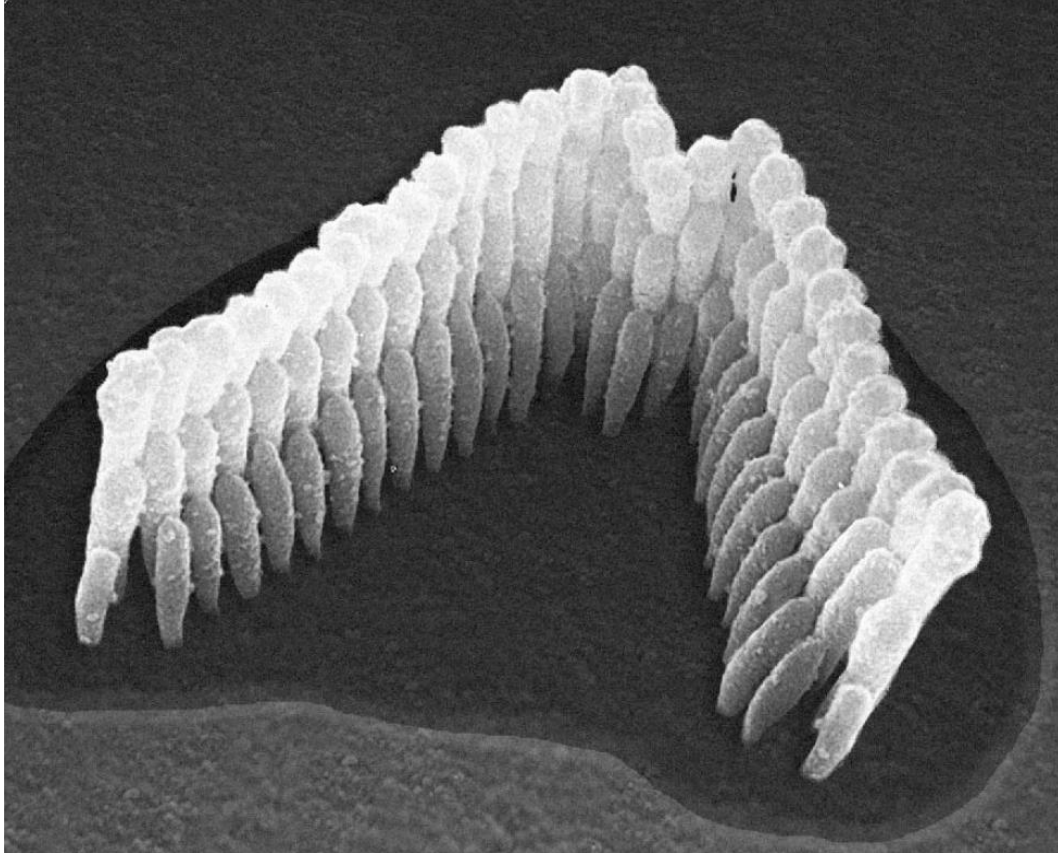
*Professor of Audiology and Speech-Language Sciences*

University of Northern Colorado

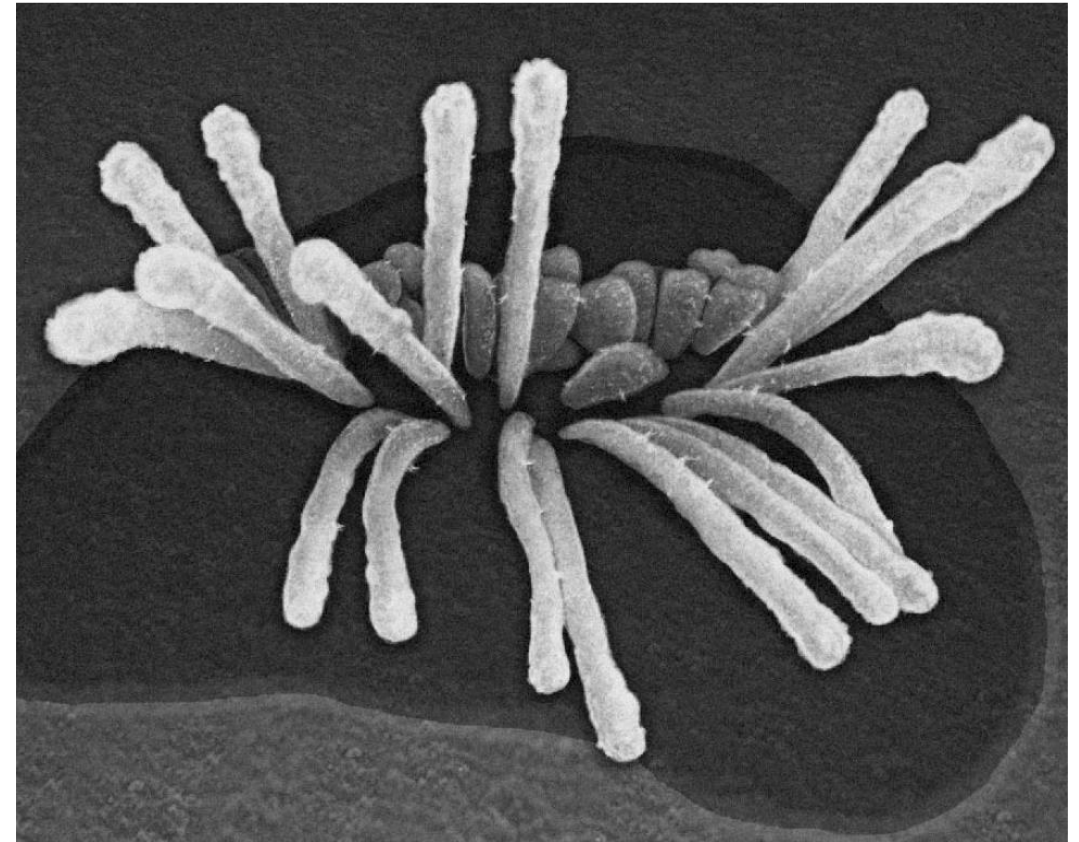
*Co-director, Dangerous Decibels®*

# Auditory System Damage: Cochlear

Healthy Hair Cell Bundle



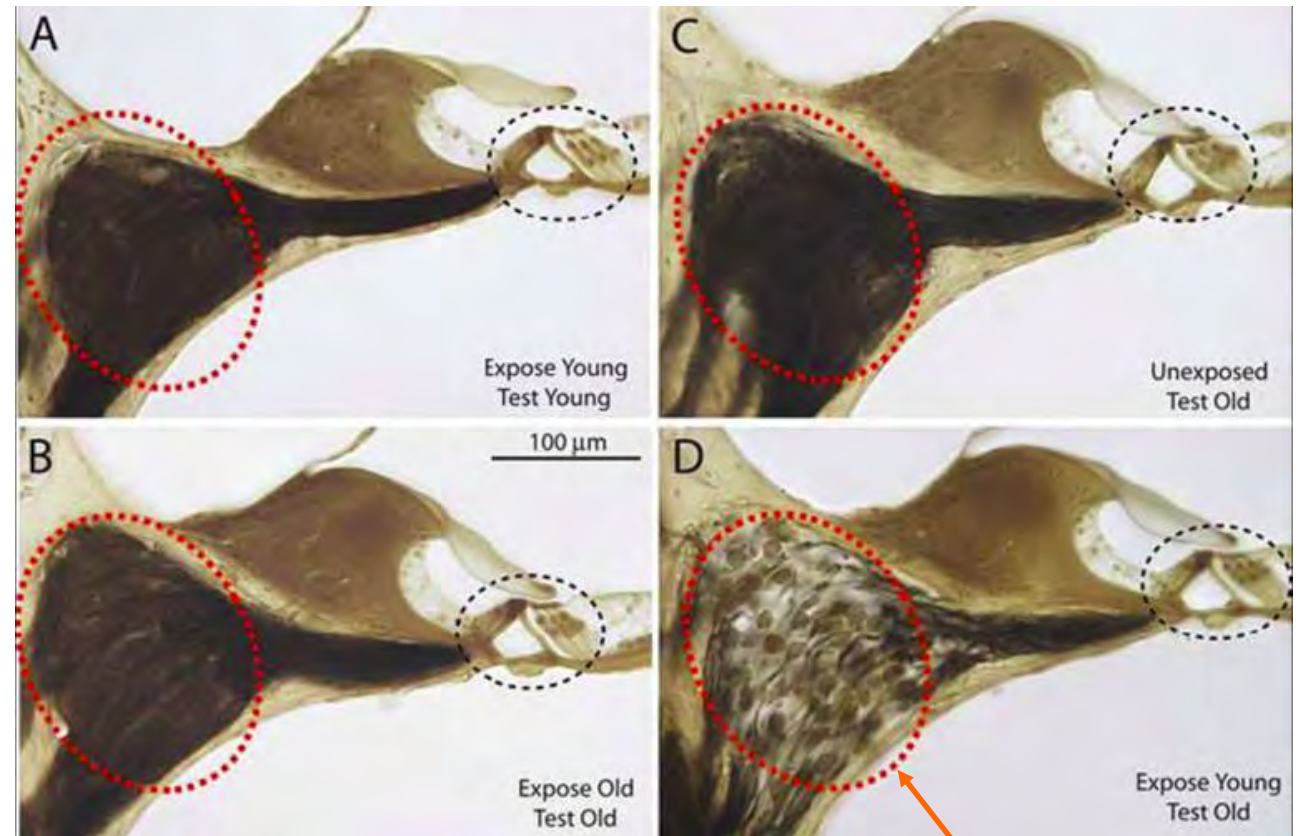
Noise Damaged Hair Cell Bundle





# Auditory System Damage: Nerve Synapses

- Cochlear neurons targeted by noise and may accelerate age-related hearing loss
- Spiral ganglion of mouse with decreased density of neurons after noise exposure when young
- “Hidden” hearing loss



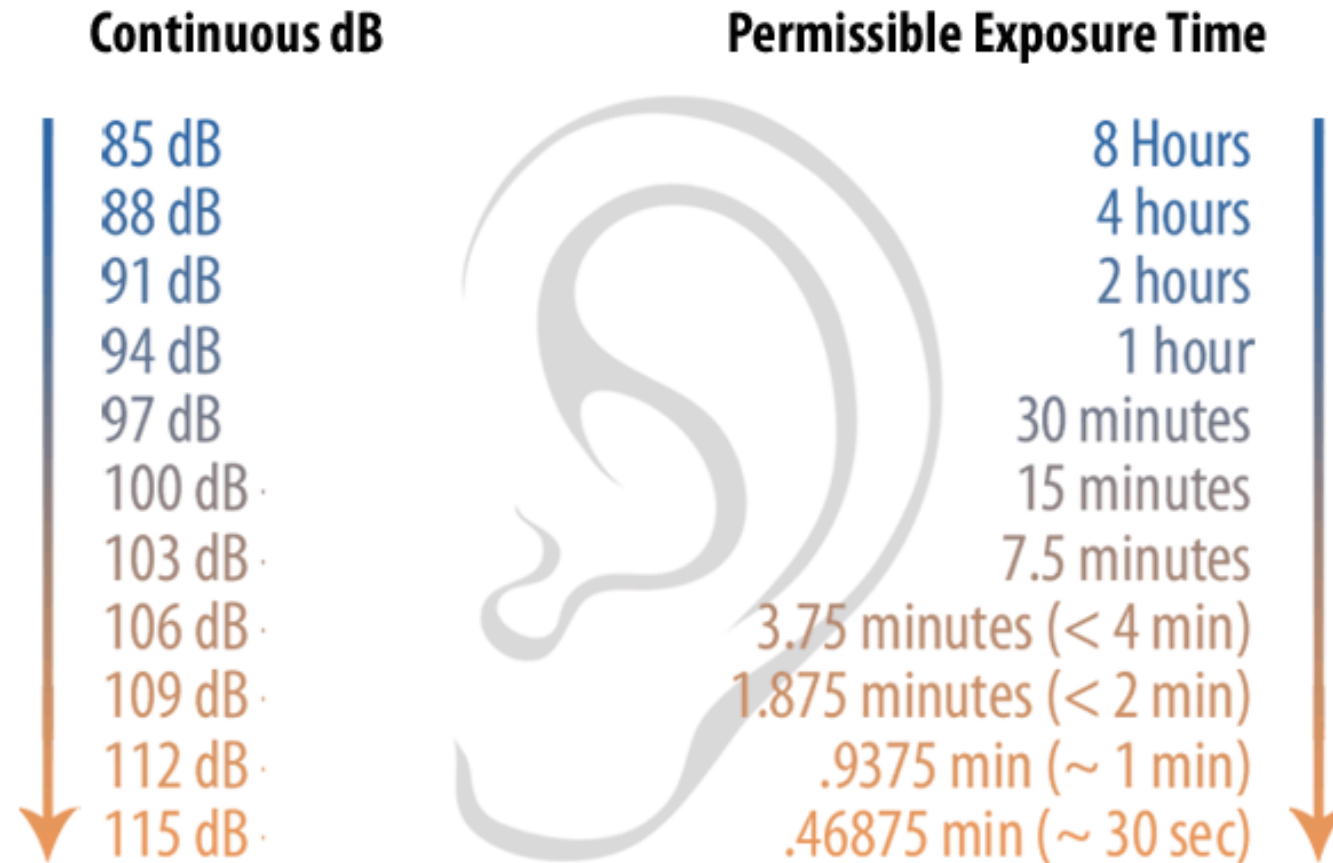
Decreased density  
of neurons

# Risk of Hearing Damage Relates to Both Loudness and Length of Time Exposed

- Noise exposure integrates A-weighted sound pressure level (decibels) and duration of listening
- Permissible exposures are based on adult occupational noise exposures with some degree of acceptable risk for repeated exposures over 40 years
- Exposure limits for children are unknown

Decibels  
+  
Time  
=  
Damage

# Noise Risks: Level + Time





# Noise Exposure Associated with No Risk of Hearing Loss

| <b>Decibels<br/>(A-weighted)</b>   | <b>Allowable Duration<br/>(hours / minutes)</b> |
|--|---|
| 70 dBA   | 24 hours  |
| <b>75 dBA</b>  | <b>8 hours</b> (480 minutes)                    |
| 85 dBA   | 47 minutes                                      |
| 95 dBA   | 4.5 minutes                                     |
| 105 dBA  | 0.5 minutes                                     |
| 115 dBA  | 0 minutes                                       |
| Integrated with equal energy rule: 3 dB exchange rate; 40-year exposure lifetime |   |

U.S. EPA. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. EPA/ONAC 550/9-74-004. Washington, DC:U.S. Environmental Protection Agency, 1974.

# High-Level Impulse Noise: Risk of Immediate Hearing Damage



**Retail Firecracker Display**

- **Acoustic trauma:** Risk of immediate mechanical damage to the unprotected auditory system from high-level impulse or impact noise
  - 140 dB peak SPL for adults (NIOSH)
  - 120 dB peak SPL for children (WHO)
  - Firecrackers:
    - At 1 meter: **162 dB peak SPL**

SPL: Sound pressure level

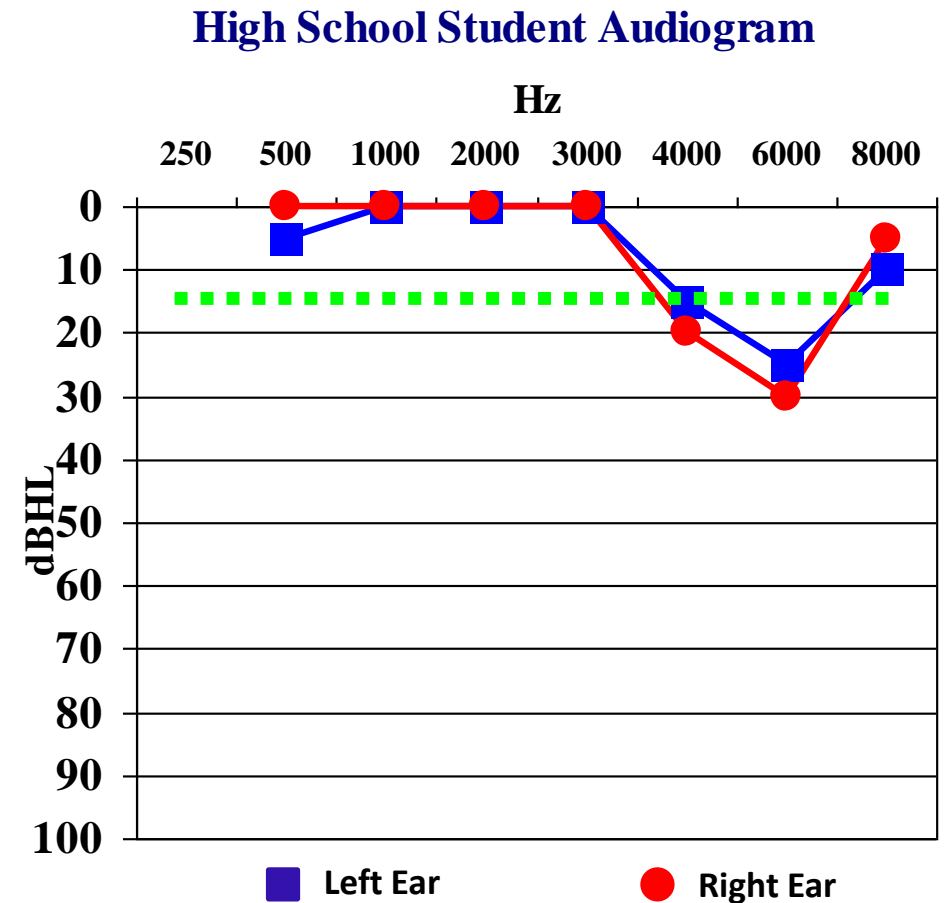
Flamme GA, Liebe K, Wong A. *Noise Health*. 2009 Oct-Dec;11(45):223-30.

Lankford JE, Meinke DK, Flamme GA, et al. *Int J Audiol*. 2016;55 Suppl 1:S51-8.

Meinke DK, Murphy WJ, Finan DS, et al. *Int J Audiol*. 2014 Mar;53 Suppl 2:S16-25.

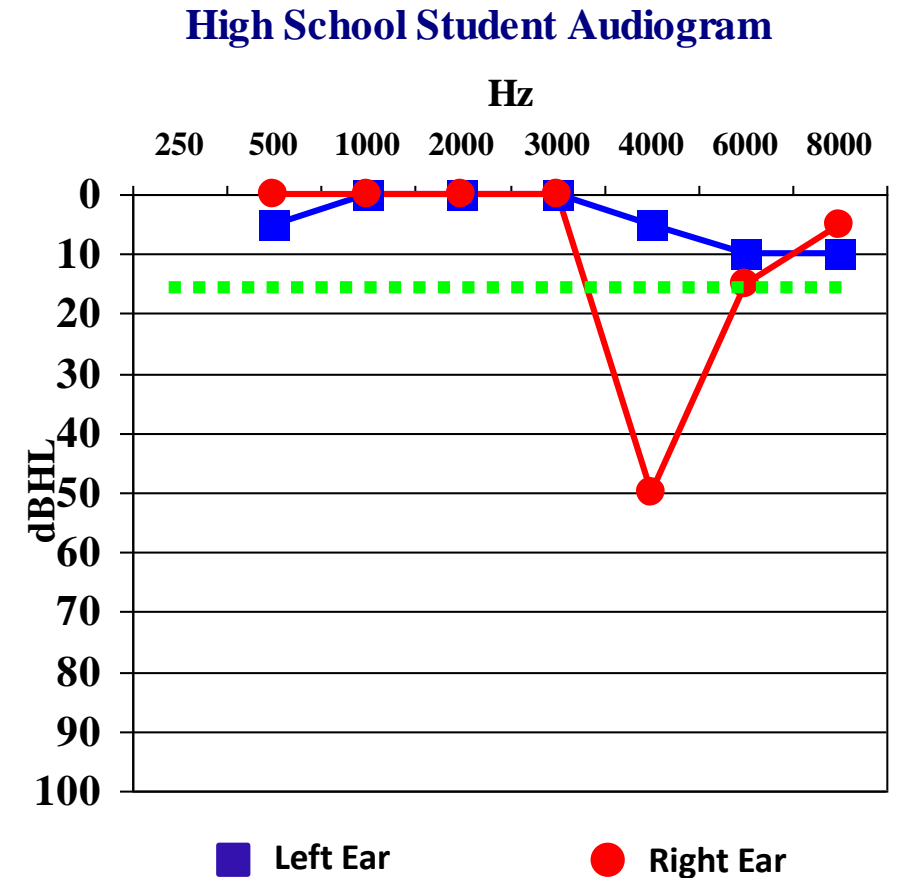
# Bilateral Noise-Induced Hearing Loss: Continuous Noise Exposure

- **Bilateral noise notch evident in high school student audiogram**
- **The Niskar et al. noise notch criteria includes all of the following:**
  - Thresholds <15 dBHL at 500 and 1000 Hz
  - A notching at 3000, 4000, or 6000 Hz of at least 15 dB poorer than the poorest threshold at 500 or 1000 Hz
  - Recovery of at least 10 dB at 8000 Hz compared to the poorest threshold at 3000, 4000, or 6000 Hz



# Unilateral Noise-Induced Hearing Loss: Acoustic Trauma (Firecracker)

- Unilateral noise notch evident in high school student audiogram
- Attributed to a firecracker blast occurring close to the right ear



# Noise-Induced Hearing Loss: Youth 12–19 years

- **Significant increase in the prevalence of noise-induced audiometric notch among female youths in 2005-2006**

| DATA YEAR | DATA SOURCE                    | MALES      | FEMALES    |
|-----------|--------------------------------|------------|------------|
| 1943      | Baltimore Maryland High School | <b>15%</b> | <b>5%</b>  |
| 1988–1994 | NHANES                         | <b>20%</b> | <b>12%</b> |
| 2005–2006 | NHANES                         | <b>17%</b> | <b>17%</b> |

Loch WE. Incidence and permanency of tonal dips in children. *Laryngoscope*, 1943; 53(5), 347 - 356.

Niskar AS, Kieszak SM, Holmes AE, et al. *Pediatrics*. 2001 Jul;108(1):40 - 3.

Henderson E, Testa MA, Hartnick C. *Pediatrics*. 2011 Jan;127(1):e39 - 46.




# Noise-Induced Hearing Loss in Youth: Is Hearing Screening Working?

- **School-based hearing screenings are inadequate for the early identification of noise-induced hearing loss**
  - 22 different hearing screening protocols are used in schools in the United States
  - Nearly 80% unable to detect early noise-induced hearing loss in youth
  - Middle and high school students are less likely to have a hearing screening performed



# Noise-Induced Tinnitus

- **Tinnitus is an early indicator of noise-induced hearing loss** 
- **Most common cause of persistent tinnitus is noise exposure**
- **Recreational and occupational noise exposure increased odds of tinnitus**
- **Prevalence of tinnitus in US teens (ages 12–19 years)**
  - 7.5% or about 2.5 million adolescents, reported tinnitus lasting 5 minutes or more in preceding 12 months
  - 4.7% or 1.6 million adolescents, reported chronic tinnitus

# Personal Audio Systems (Music Players)



- **Average maximum output levels**
  - 97–103 decibels A-weighted (dBA)
- **Risk estimates for youth based on listening time**
  - 14%–30% at risk of music-induced hearing loss
- **Males listen louder than females**
  - Males: mean 80.6 dBA
  - Females: mean 75.3 dBA
- **Volume settings below 60% of maximum permit unlimited listening**

Punch JL, Efenbein JL, James RR. *Am J Audiol*. 2011 Jun;20(1):69-82.

Portnuff CD, Fligor BJ, Arehart KH. *J Am Acad Audiol*. 2011 Nov-Dec;22(10):663-77.

# Longstanding Need for Hearing Health Promotion

## ➤ Noise and Hearing Loss. NIH Consensus Statement 1990

- *“A comprehensive program of education regarding the causes and prevention of noise-induced hearing loss should be developed and disseminated, with specific attention directed toward educating school-age children.”*

## ➤ Healthy People 2020

- *Increase the proportion of elementary, middle, and senior high schools that provide school health education in ways to prevent vision and hearing loss to promote personal health and wellness.*



# Application of Health Communication Science to Promote Hearing Health

- The goal is to *change behavior*
- **3 levels of behavior change theories**
  - Intrapersonal
  - Interpersonal
  - Community-level
- **Application of theory provides a framework to change individual knowledge, attitudes, beliefs, and behaviors**





# Evidence-Based Dangerous Decibels® Program

- **Intervention program for the prevention of noise-induced hearing loss and tinnitus**
- **Shown to be effective in the U.S., New Zealand, and Brazil**
  - Randomized trials and observational studies
  - Documented changes in knowledge, attitudes, and behaviors for youth and adults



Griest SE, Folmer RL, Martin WH. *Audiol.* 2007 Dec;16(2):S165 - 81.  
Martin WH, Griest SE, Sobel JL, et al. *Int J Audiol.* 2013 Feb;52 Suppl 1:S41 - 9.  
Knobel KA, Lima MC. *Int J Audiol.* 2014 Mar;53 Suppl 2:S35 - 42  
Reddy R, Welch D, Ameratunga S, et al. *Int J Audiol.* 2017 Jan 12:1 - 12.

Developed with grant support from CDC



# Evidence-Based Dangerous Decibels® Program

- Originally developed for youth, and now adapted for adults and the military
- Shown to be self-sustaining in U.S. Native American communities
- Incorporates three strategies for hearing loss prevention

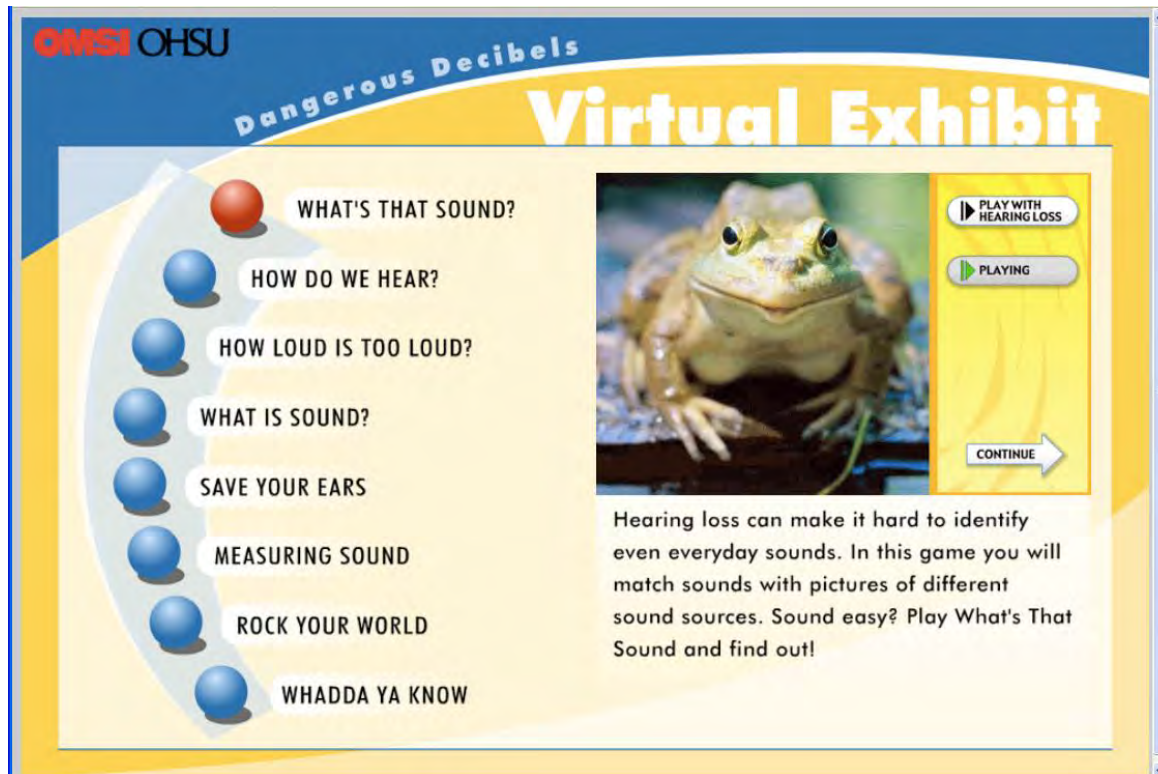




# Dangerous Decibels® Resources



## Web-based games and activities



## Jolene: educational manikin measures music listening levels



Martin, WH. *Semin Hear* 2008; 29(1): 102 - 110.

Martin WH, Martin GY. *Hearing loss: 9th International Congress on Noise as a Public Health Problem (ICBEN)*. Foxwoods, CT. 2008.

Developed with grant support from CDC



# Hearing Health Among Adults



**William J. Murphy, PhD**

*Research Physicist*

Hearing Loss Prevention Research Cross Sector

National Occupational Research Agenda

National Institute for Occupational Safety and Health

# Hearing Loss Risk Factors

- **Continuous noise (>85 dB SPL)**
- **Impulsive noise (not continuous)**
- **Ototoxic chemicals**
- **Physiologic factors**
  - Individual susceptibility to noise exposure
  - Long-term aftereffects of noise exposure





# Excessive Noise Exposures

## ➤ Impulse and impact noise peak sound pressure level (SPL)

- Police, military, security (140 to 175 dB peak SPL)
- Forge worker, blacksmith (120 to 150 dB peak SPL)
- Firecrackers and fireworks (120 to 165 dB peak SPL)

## ➤ Continuous noise exposures (at work and home)

- Manufacturing factory noise (80 to 105 dB SPL)
- Firefighters, loggers (90 to 110 dB SPL)
- Construction workers (70 to 120 SPL)
- Lawn care workers (70 to 95 dB SPL)



dB: Decibels

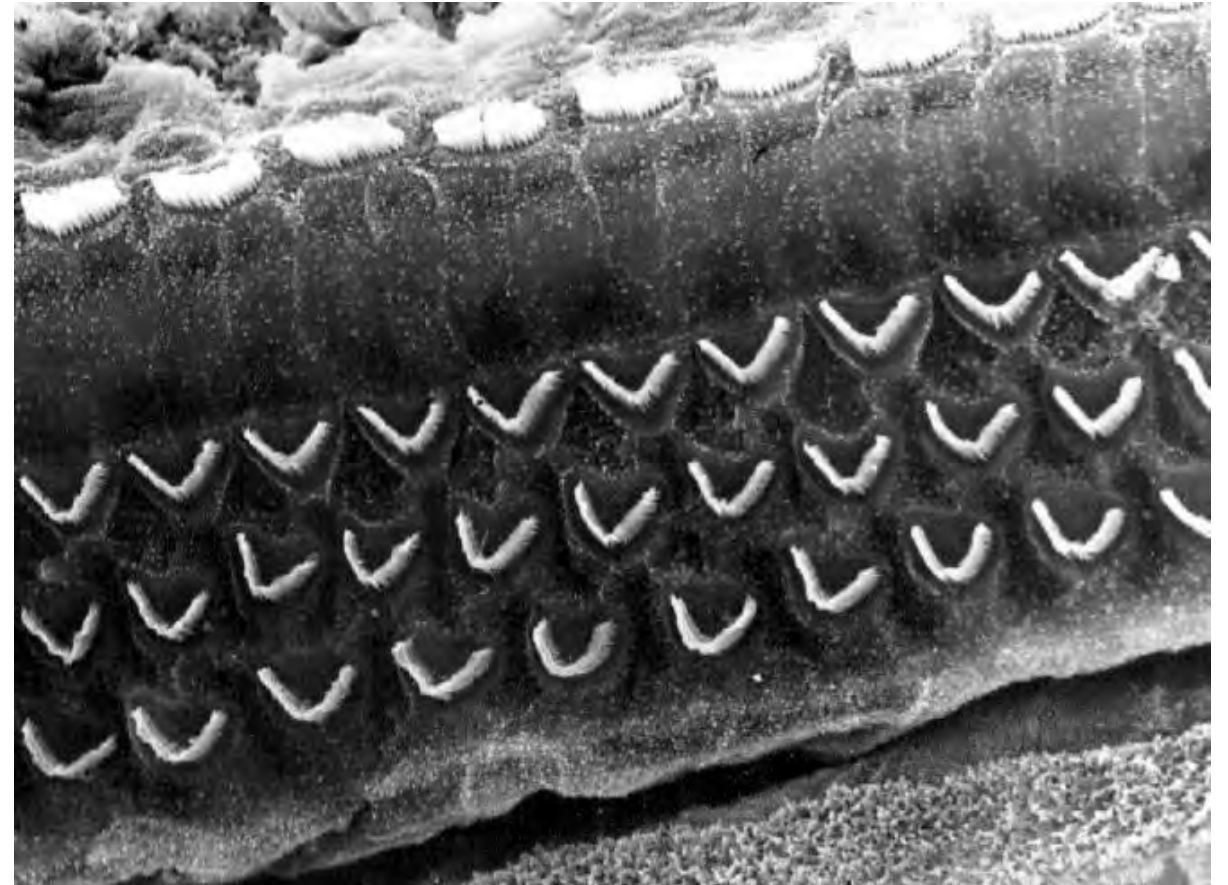
Flamme GA, Liebe K, Wong A. *Noise Health*. 2009 Oct-Dec;11(45):223-30.

Flamme GA, Wong A, Liebe K, et al. *Noise Health*. 2009 Oct-Dec;11(45):231-42.

[www.cdc.gov/nceh/hearing\\_loss/infographic/](http://www.cdc.gov/nceh/hearing_loss/infographic/)

# Ototoxic Substances Damage Hearing in Different Ways

- **Examples of substances that can affect hearing**
  - Medications (e.g., aminoglycoside antibiotics)
  - Solvents (e.g., toluene, styrene)
  - Heavy metals (e.g., lead, mercury)
  - Asphyxiants
  - Pesticides

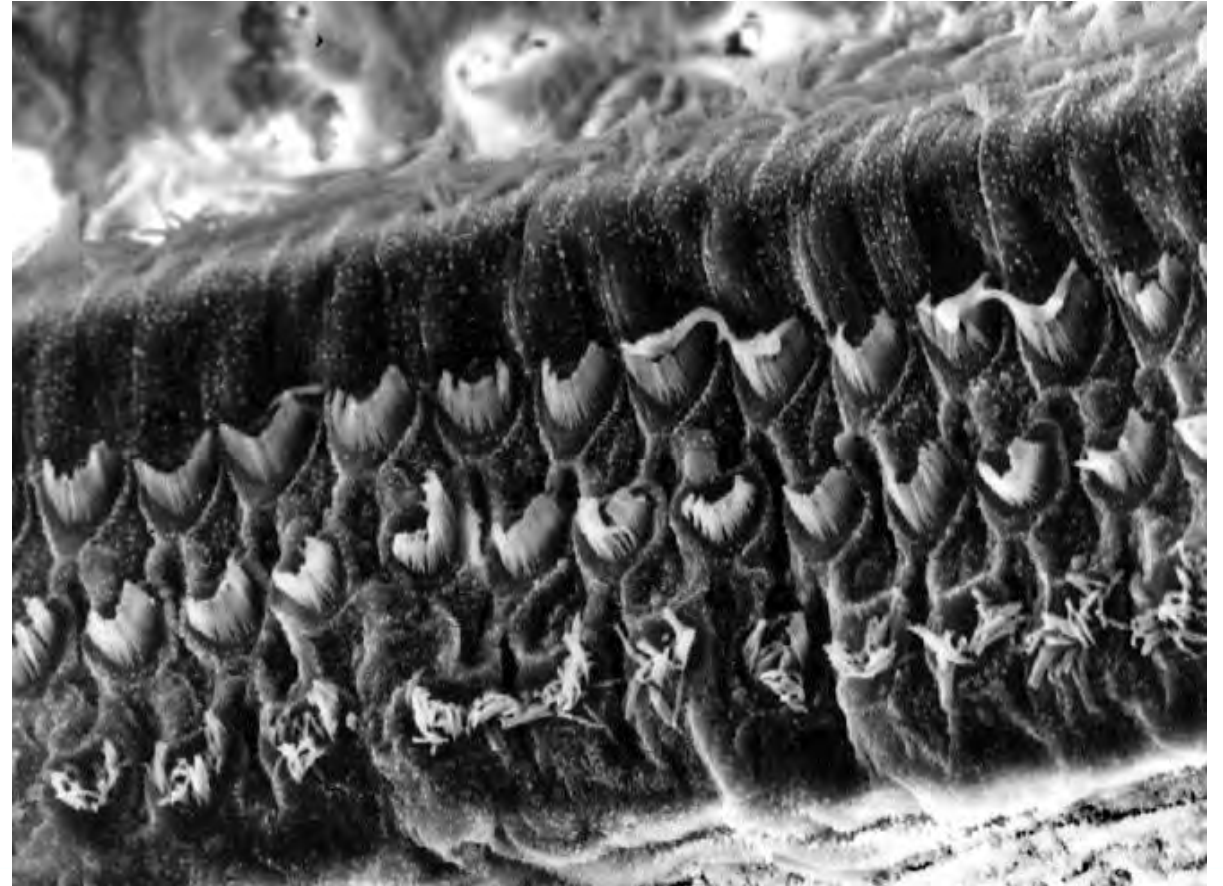


Normal Outer/Inner Hair Cells

# Ototoxic Substances Damage Hearing in Different Ways

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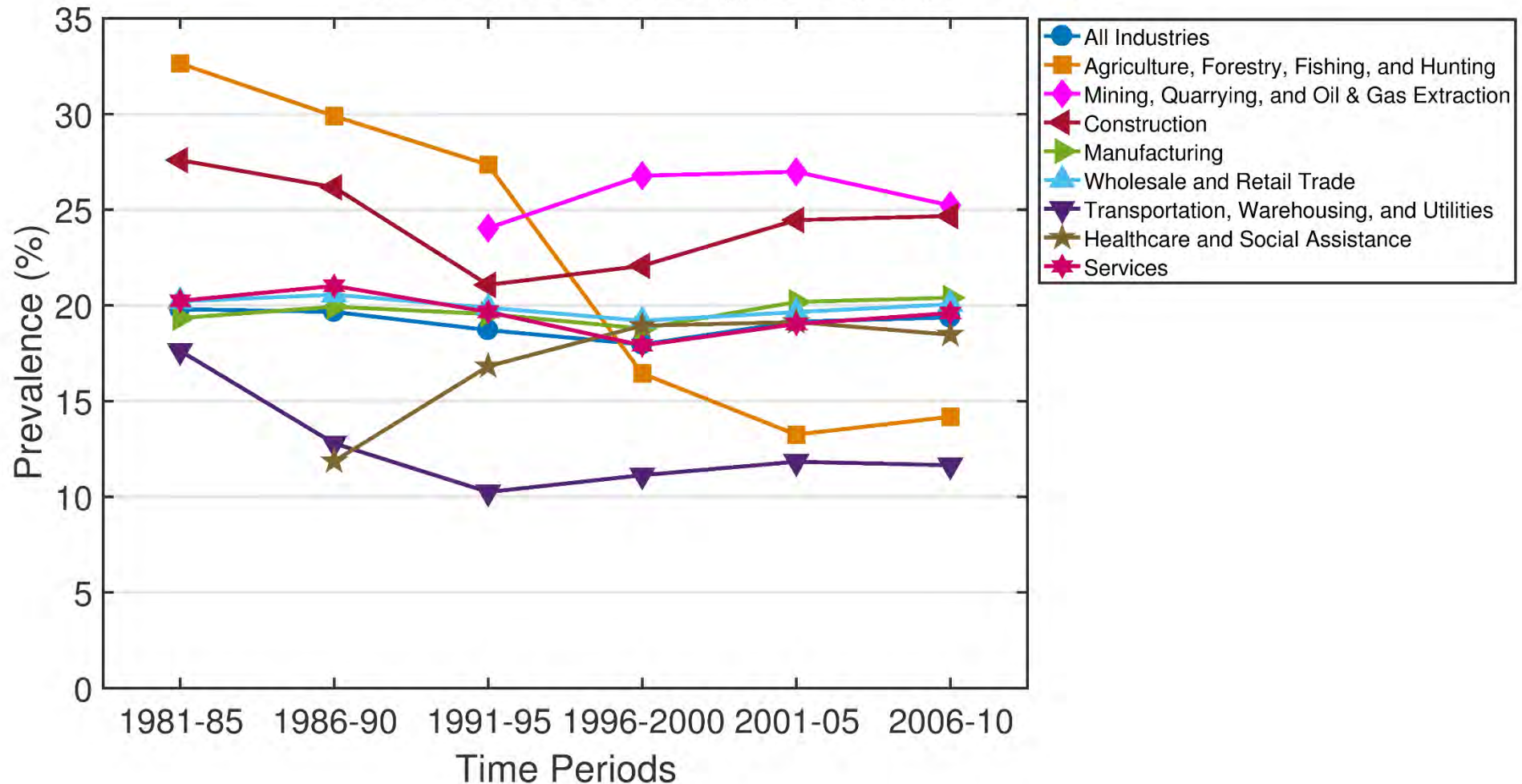


Damaged Outer/Inner Hair cells



# Occupational Hearing Loss Prevalence Varies Between 12–25%

**Estimated Prevalence of Hearing Loss by Time Period and Industry Sector  
1981-2010 for Noise-exposed 1,816,812 workers**



# Some Industries Sectors Still Have High Levels of Noise Exposure

## Prevalence of workers self-reported hazardous noise exposure

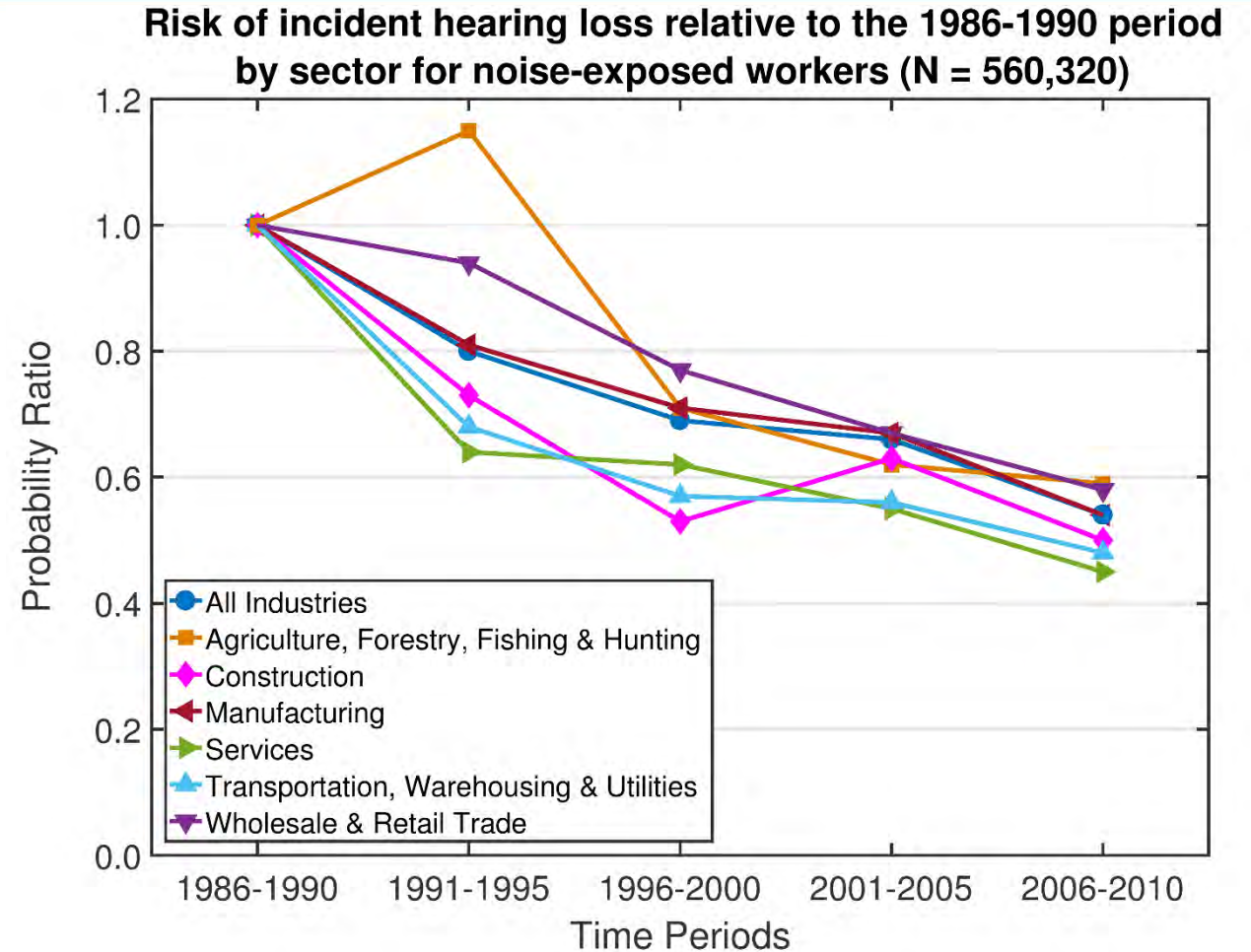
- 76% of miners
- 55% of lumber and wood
- 48% of rubber, plastics and leather
- 46% of utilities
- 45% of repair and maintenance
- 44% of construction trades





# Hearing Loss Due to Occupational Exposure Is Decreasing

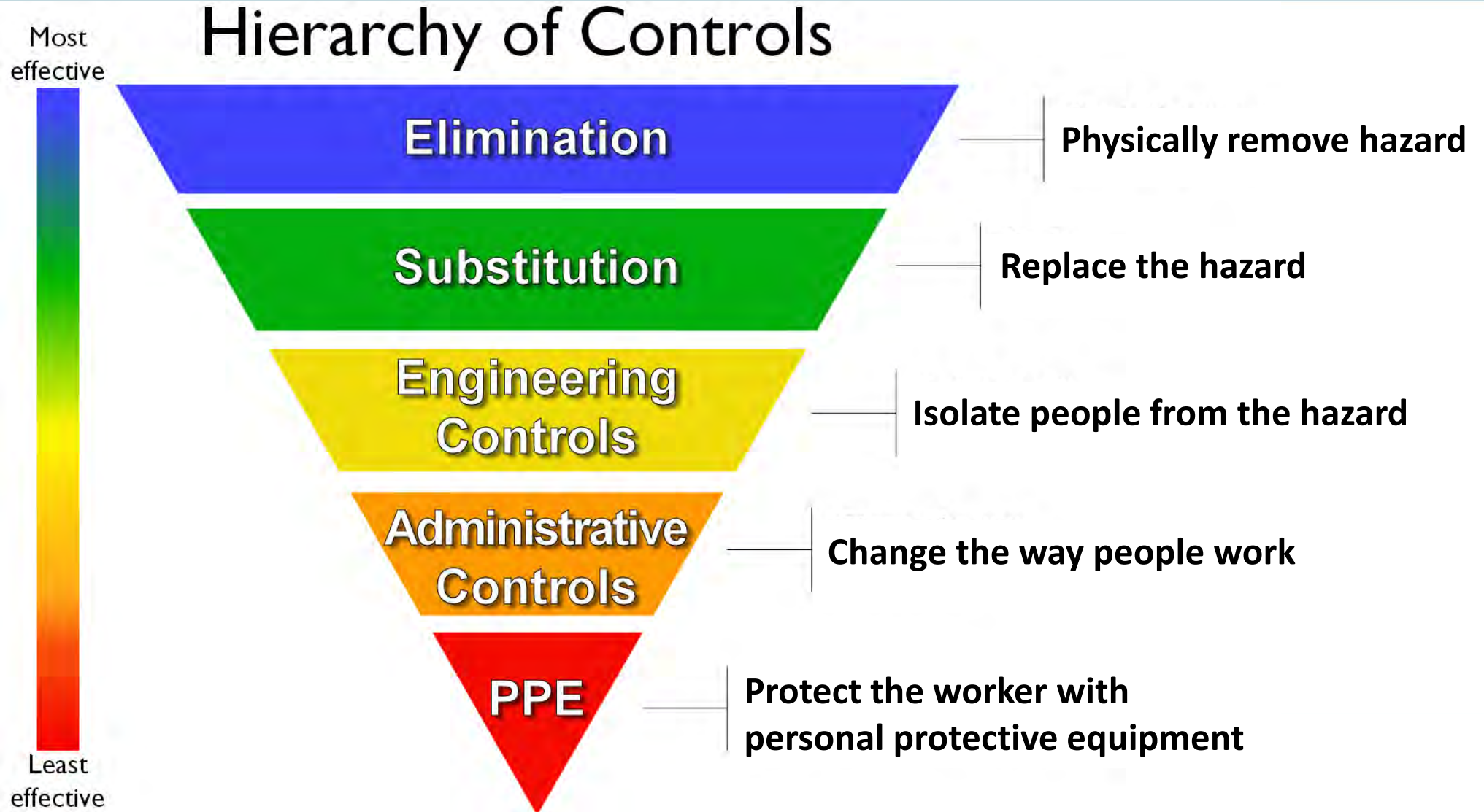
- From 2004 to 2015, fewer workers have had occupational hearing loss
  - Reduction from 28,000 to 18,000
- However, 22 million workers are exposed to hazardous levels of noise (NHANES)



# Current U.S. Hearing Impairment Statistics

- **Estimated 31%, or 61.1 million people, in the US have high-frequency hearing impairment (>25 dB average @ 3, 4, and 6 kHz)**
- **Men had more than twice the prevalence of high-frequency hearing impairment (28% or 26.9 million) as did women (11% or 11.1 million)**
- **Significant risk factors include**
  - Age 60-69 years
  - Non-Hispanic White
  - Non-Hispanic Asian
  - Occupational noise very loud (>5 years)
  - Less than high school education

# Engineering Control of Noise



# Interventions and their Effectiveness

- **Audiometric screening and testing**
- **Fit testing for hearing protection devices**
- **Buy Quiet programs**
- **NIOSH and NHCA Safe-in-Sound Award for Excellence in Hearing Loss Prevention**
- **Evidence-based best practices and systematic reviews**

# New Technology Can Improve How Hearing Is Tested

## ➤ **Wireless technology**

- Eliminates the need for expensive testing booths
- Removes barriers for safety and health professionals to conduct annual audiometric screening

## ➤ **Mobile devices**

- Test speech intelligibility in addition to audiometric screening
- Train and educate people about hearing health



**Audiometric Headphones**



# Fit-Testing Can Improve How Hearing Protection Is Used

**Noise Reduction Ratings (NRR) do not represent what individual users achieve**

- **Surveys of hearing protector use indicate less than half of users achieve an adequate level of protection**
- **Fit-testing informs the user how well their protectors work through a Personal Attenuation Rating (PAR)**
- **Accurate ratings for advanced hearing protection device technology**



# What is Buy Quiet?

**A prevention initiative which**

- **Encourages companies to use quieter machinery and tools to reduce worker noise exposure**
- **Provides information on equipment noise levels, so companies can buy quieter products**
- **Encourages manufacturers to design quieter equipment by creating demand for quieter products**



# Benefits of Buy Quiet

- **Reducing the risk of hearing loss**
- **Reducing the long-term costs of audiometric testing, personal protective equipment, and workers' compensation**
  - When purchasing products, for each decibel quieter, conservative estimates show \$100 in savings
  - This savings is applicable across a variety of machinery and equipment
- **Helping companies comply with OSHA and other noise regulation requirements**



# Additional Benefits of Buy Quiet

- **Quieter workplace improves**
  - Employee communication
  - Worker safety
- **Quieter tools and products reduce the impact of noise on the community**
  - Noise annoyance is a factor in many types of outdoor work

**Buying a tool  
just 3 decibels  
lower will cut the  
noise energy  
reaching your  
ear in half!**

# Safe-In-Sound Excellence in Hearing Loss Prevention Award™

- Recognize excellence and innovation in hearing-loss prevention
- Promotes solutions for noise control and hearing-loss prevention
- Program partnered with National Hearing Conservation Association
- Ninth year of the program





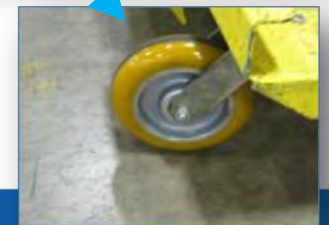
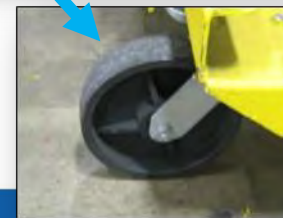
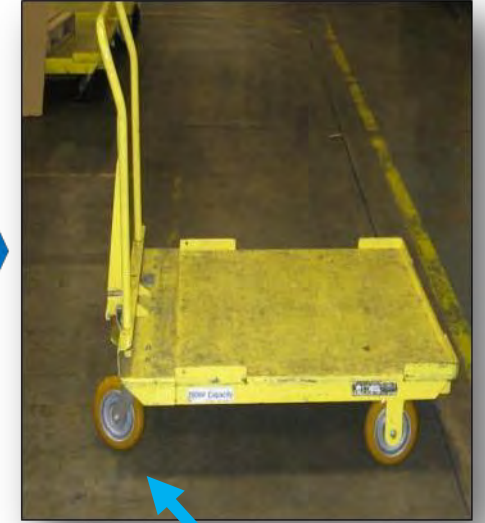
# Safe-In-Sound Award Winners

➤ Since 2009:

- Twenty organizations awarded
- Manufacturing, services, innovation, construction sectors all represented
- Corporations, state and local government entities included
- Dangerous Decibels® won in 2013

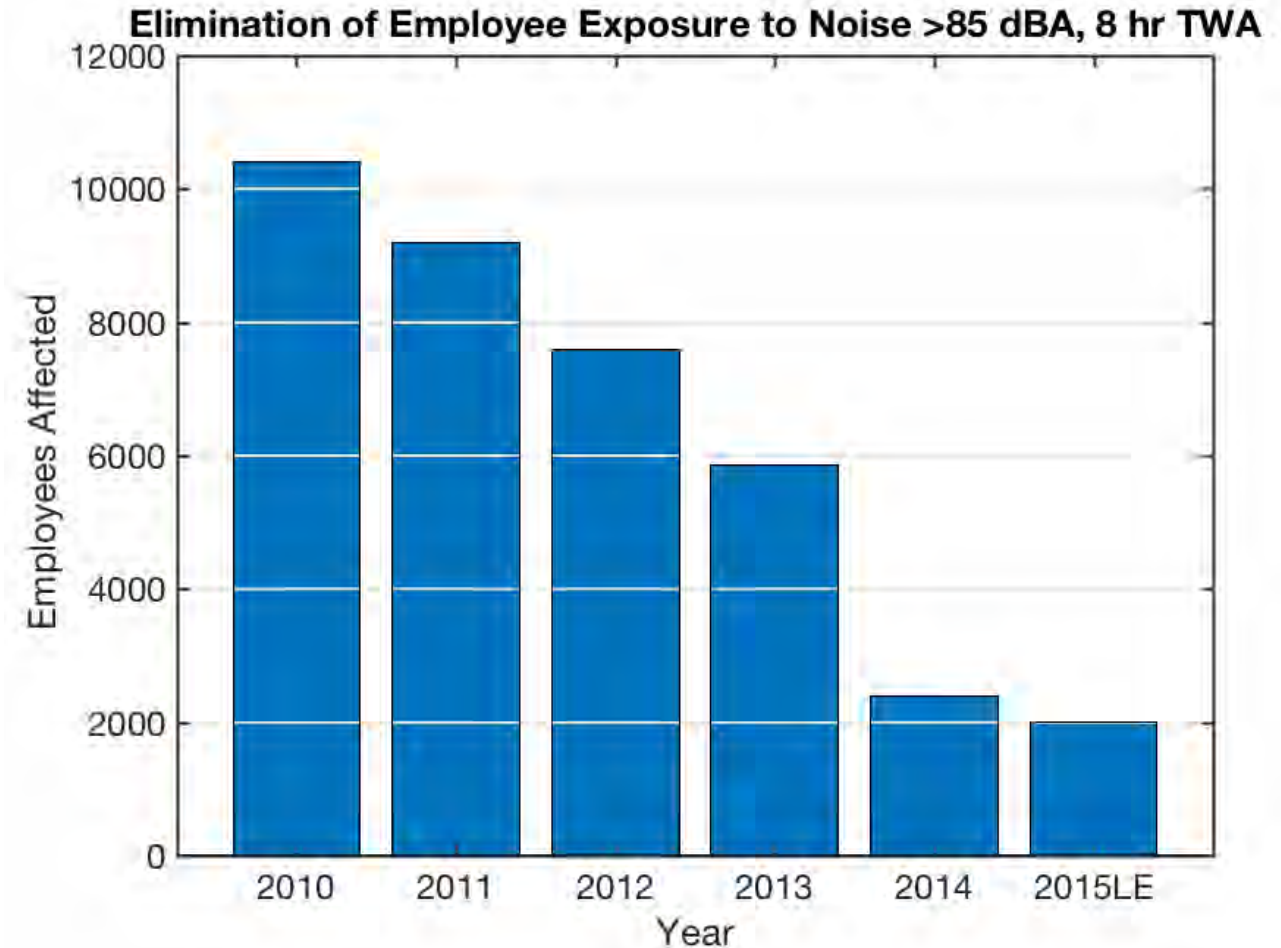
**Before: 88 dBA**

**After: 72 dBA**



# Noise Control Is Achievable and Desirable

- **2009 Pratt & Whitney (jet engine manufacturer) received Safe-In-Sound Award**
- **2015 United Technologies (parent company) eliminated hazardous noise exposures for more than 8000 workers**
- **United Technologies used Buy Quiet to reduce employee exposures**



# NIOSH Sound Level Meter Application

- **Mobile devices can accurately measure noise exposures**
  - Microphone must be calibrated
- **NIOSH developed the Sound Level Meter App for iOS**
  - [www.cdc.gov/niosh/topics/noise/app.html](http://www.cdc.gov/niosh/topics/noise/app.html)
- **Informs both consumers and workers about noise exposures**



# Hearing Loss Prevention for Both the Workplace and the Home



- **Know your noise exposures: use the app**
- **Find ways to control these exposures**
  - Eliminate, avoid, reduce, protect
- **Wear hearing protection properly and whenever exposures exceed 85 dB SPL**



SPL: sound pressure level

## It Works!



# Hearing Health Across the Lifespan



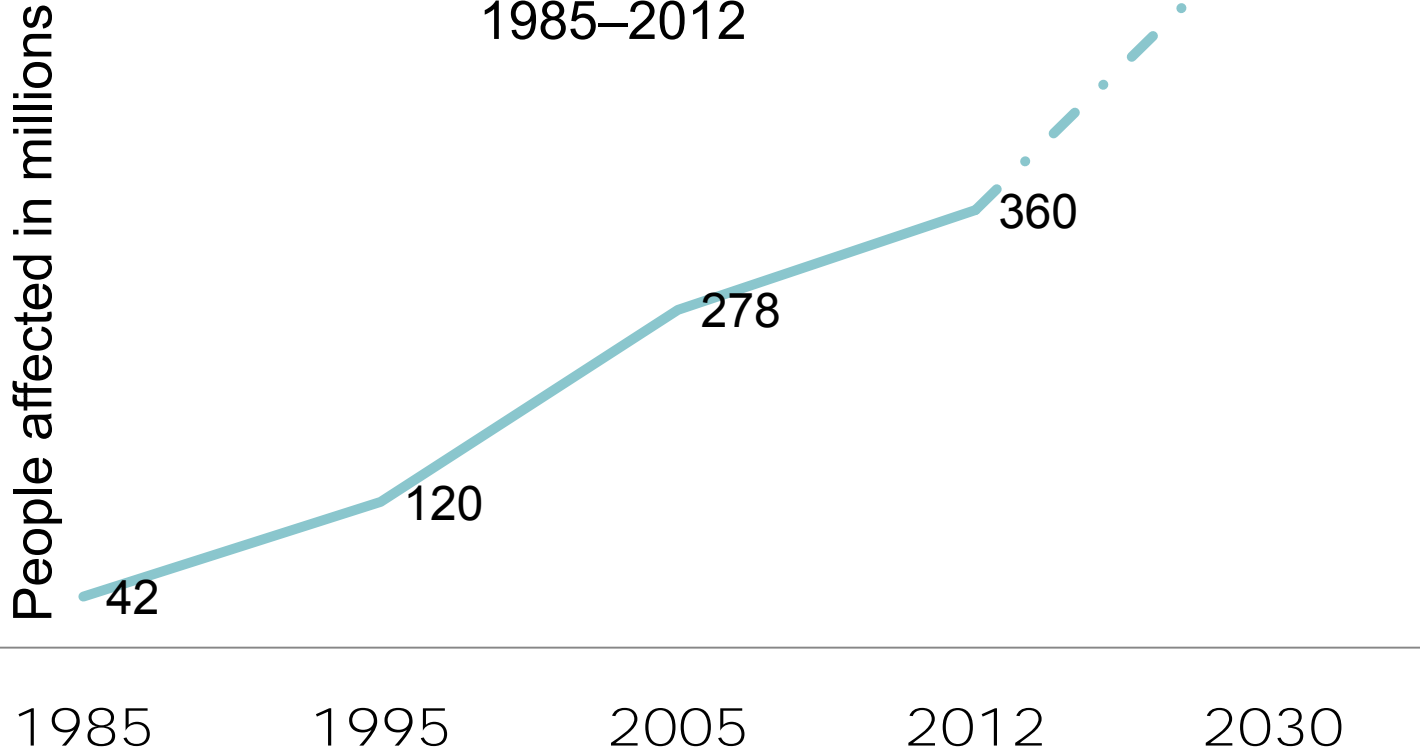
**Shelly Chadha, MBBS, PhD**

*Technical Officer, Programme on Deafness and Hearing*

World Health Organization

# Is Hearing Loss an Impending Epidemic?

Trends in disabling hearing loss:  
1985–2012

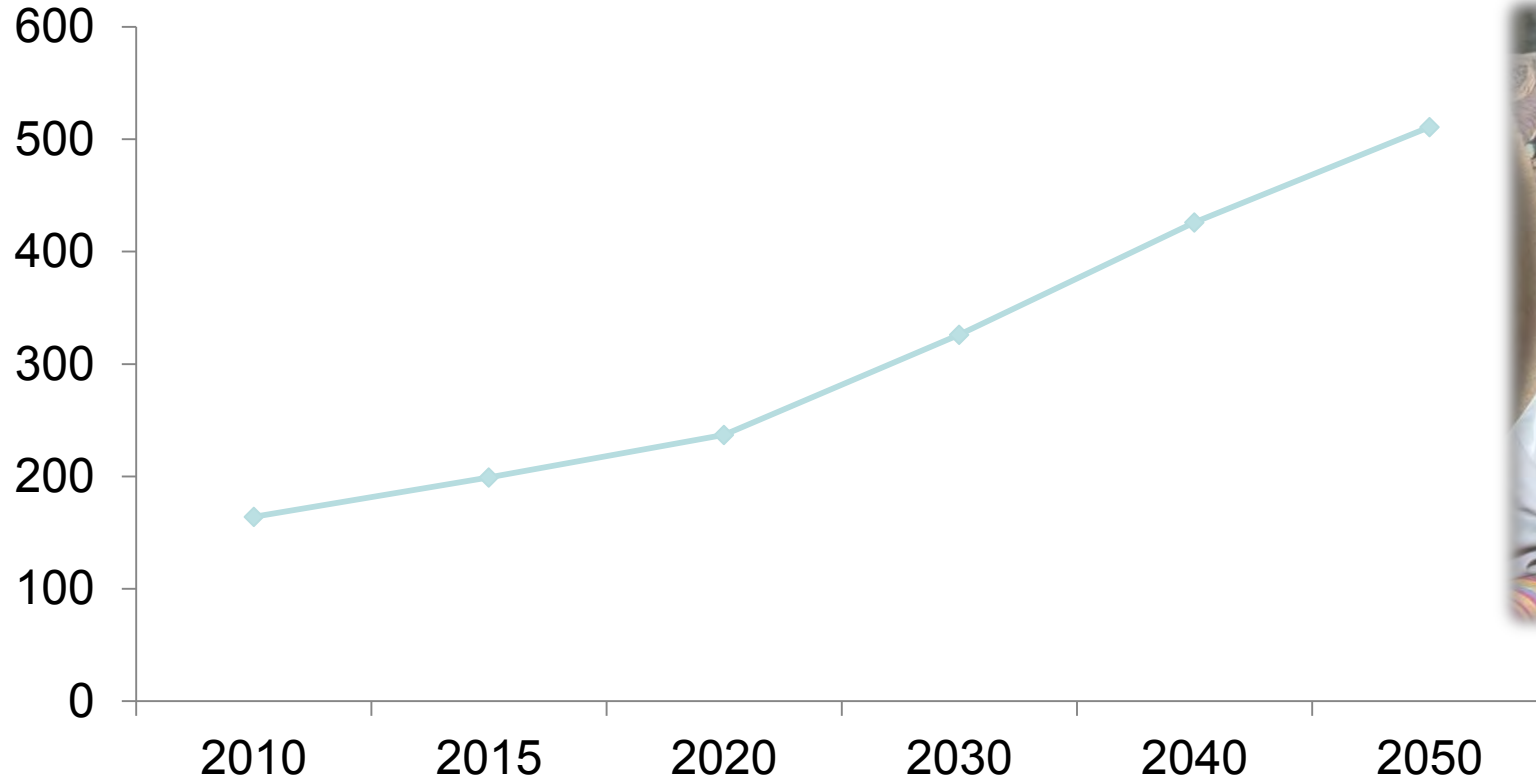


➤ **360 million live with disabling hearing loss**



# 1 in 3 Older Adults Have Hearing Loss

Projected number of older adults with hearing loss (in millions)\*



\*: projection based on expected population growth and considering a stable prevalence of DHL

# 1.1 Billion Young People Are at Risk

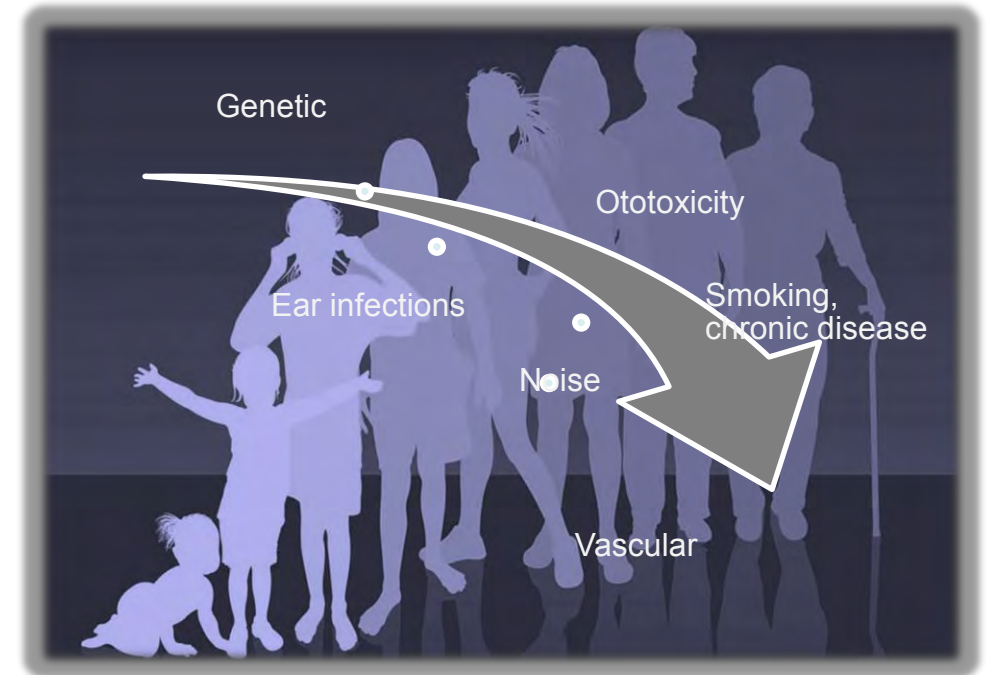


- **Over a billion are at risk of hearing loss due to non-occupational exposure to loud sounds, including music.**



# Persistence of Other Risk Factors

- **Ear infections**
- **Occupational noise exposure**
- **Use of ototoxic medicines**
- **Infectious diseases (rubella, meningitis)**
- **Chronic diseases and tobacco use**
- **Birth complications**
- **Hereditary or genetic hearing loss**



# Hearing Loss Has Consequences

## ➤ Diminished

- Communication
- Cognition
- Education
- Employment
- Social interaction
- Emotional well-being
- Economic productivity



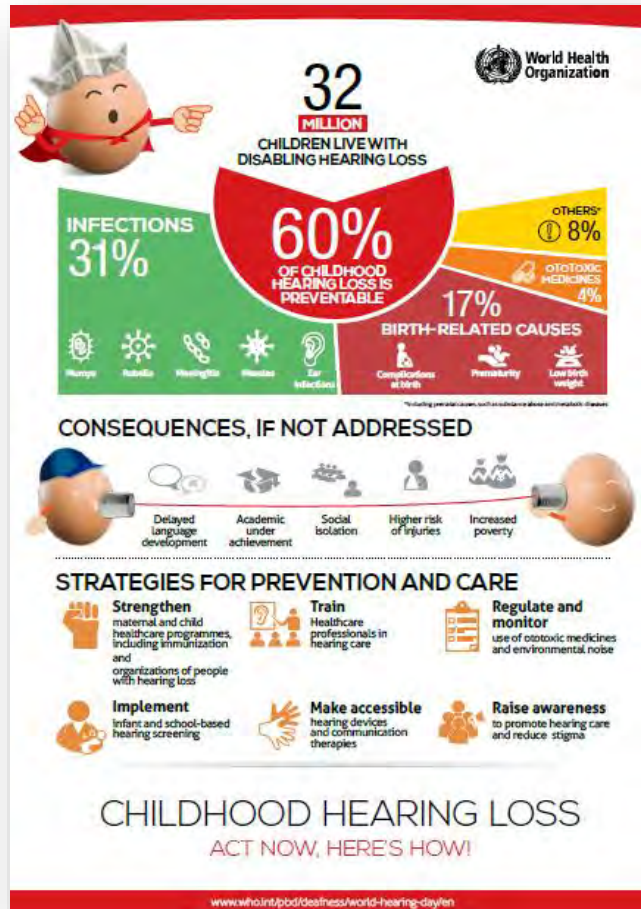
**\$750  
billion**

# Can We Control this Epidemic?



- **Many of the causes that lead to hearing loss are preventable**
- **When hearing loss occurs, its impact can be decreased by timely and suitable interventions**

# How Can We Control this Epidemic?



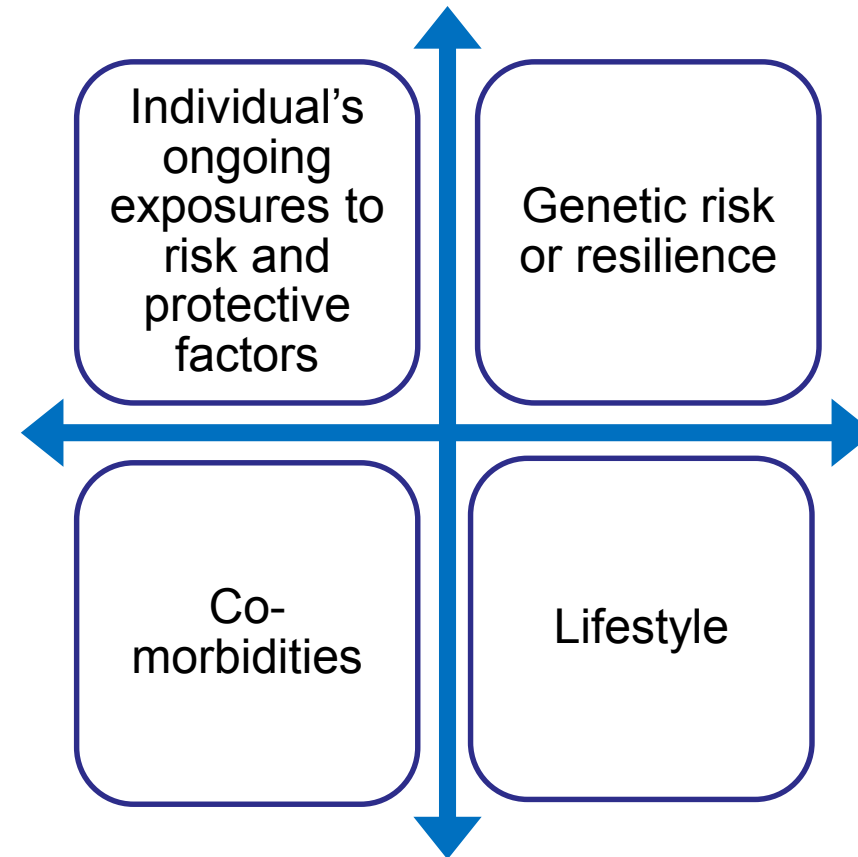
- Treat it as a public health issue
- Apply the life-course lens to hearing loss



# Applying the Life Course Lens

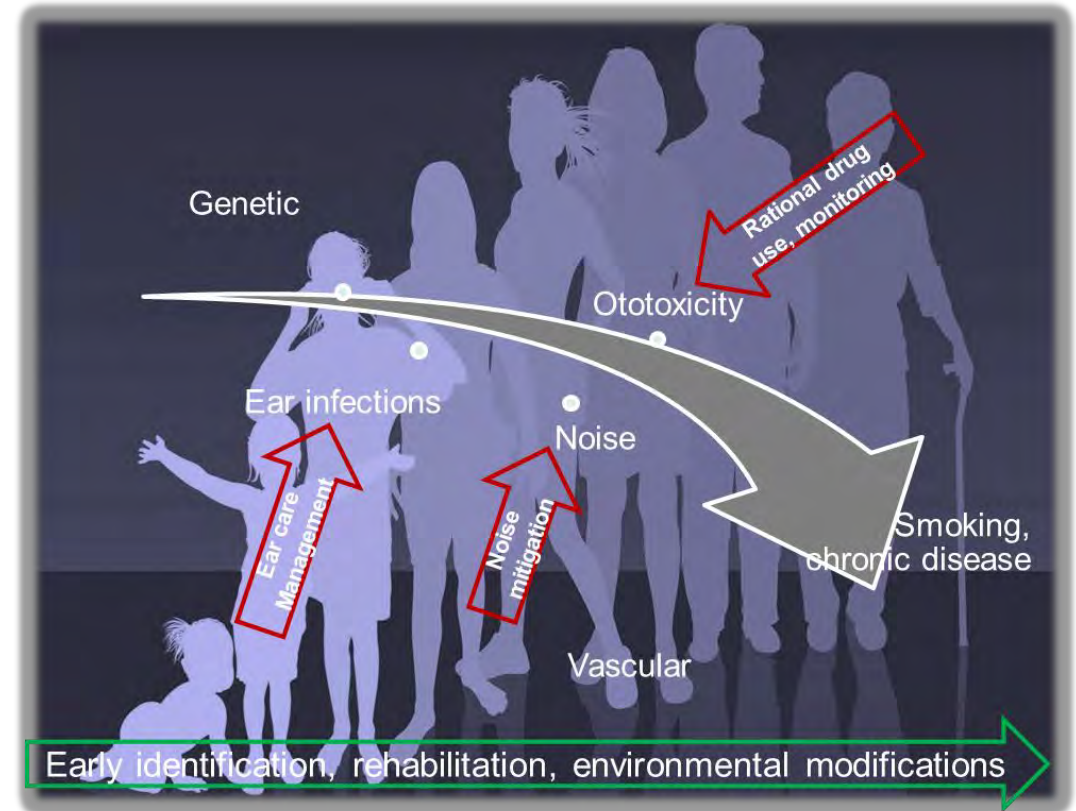
...allows us to understand that many factors affect hearing health over the course of one's life

Trajectories in hearing health will depend on



# Understand Risk Factors and Identify Opportunities for Intervention

- **Opportunities for prevention exist**
  - Risk reduction:
    - ❑ Noise control
    - ❑ Management of ear infections
    - ❑ Rational drug use
    - ❑ Ear care
  - Addressing co-morbidities
  - Lifestyle changes
- **Early identification and rehabilitation helps**



# Address Hearing Loss As a Public Health Issue

Public health approach is a population-based approach.



# World Health Organization's Approach

## Evidence-based advocacy

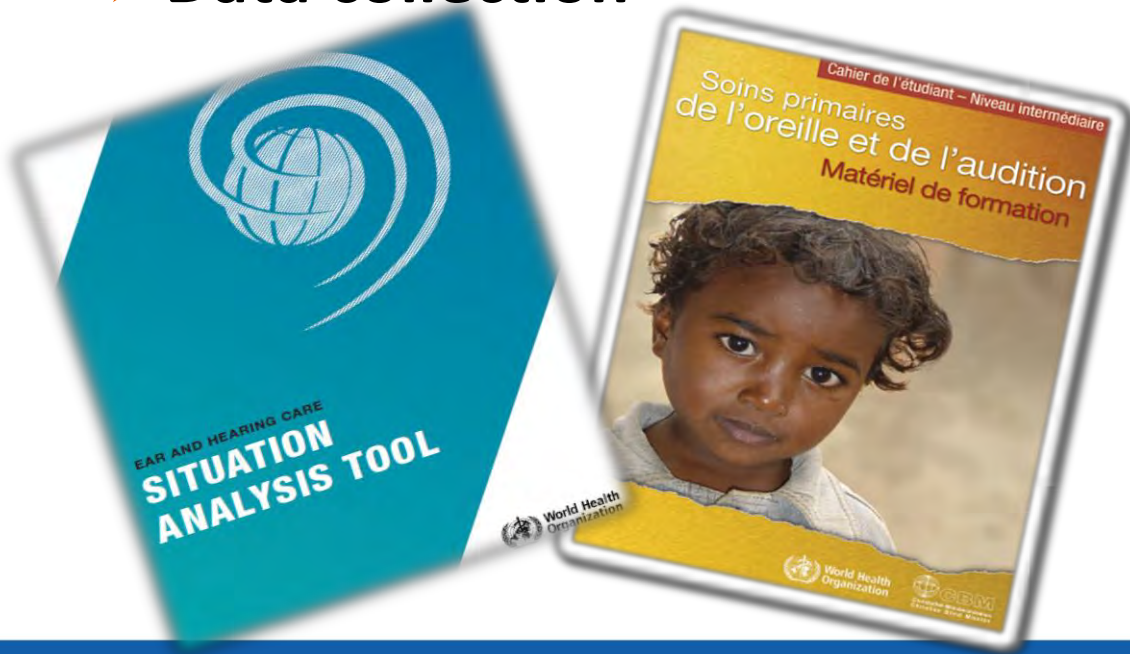
- **To raise awareness about hearing loss and hearing care at all levels**

## Member State support

- **Providing technical support to countries for development and implementation of ear and hearing care policies and strategies**

# Support for policy development

- Developing standardized, evidence-based technical tools
- Data collection



- Engaging directly with ministries of health and other stakeholders in countries to develop, implement and monitor strategies for ear and hearing care.





# Two Key Advocacy Initiatives

## ➤ World Hearing Day



*World Hearing Day*

## ➤ Make Listening Safe



*Make Listening Safe*

# Key Initiative: Make Listening Safe

**Aim: to reduce the growing risk of hearing loss posed by unsafe listening practices in recreational settings:**

➤ **Communication**

- Raising awareness
- Promoting behaviour change among users

➤ **Technology**

- Safe listening devices
- Apps for safe listening



# Key Initiative: World Hearing Day, 3 March

**Aim: to raise awareness about hearing loss at all levels: policymakers, professionals, community....**



# Key Initiative: World Hearing Day, 3 March

## ➤ Themes:

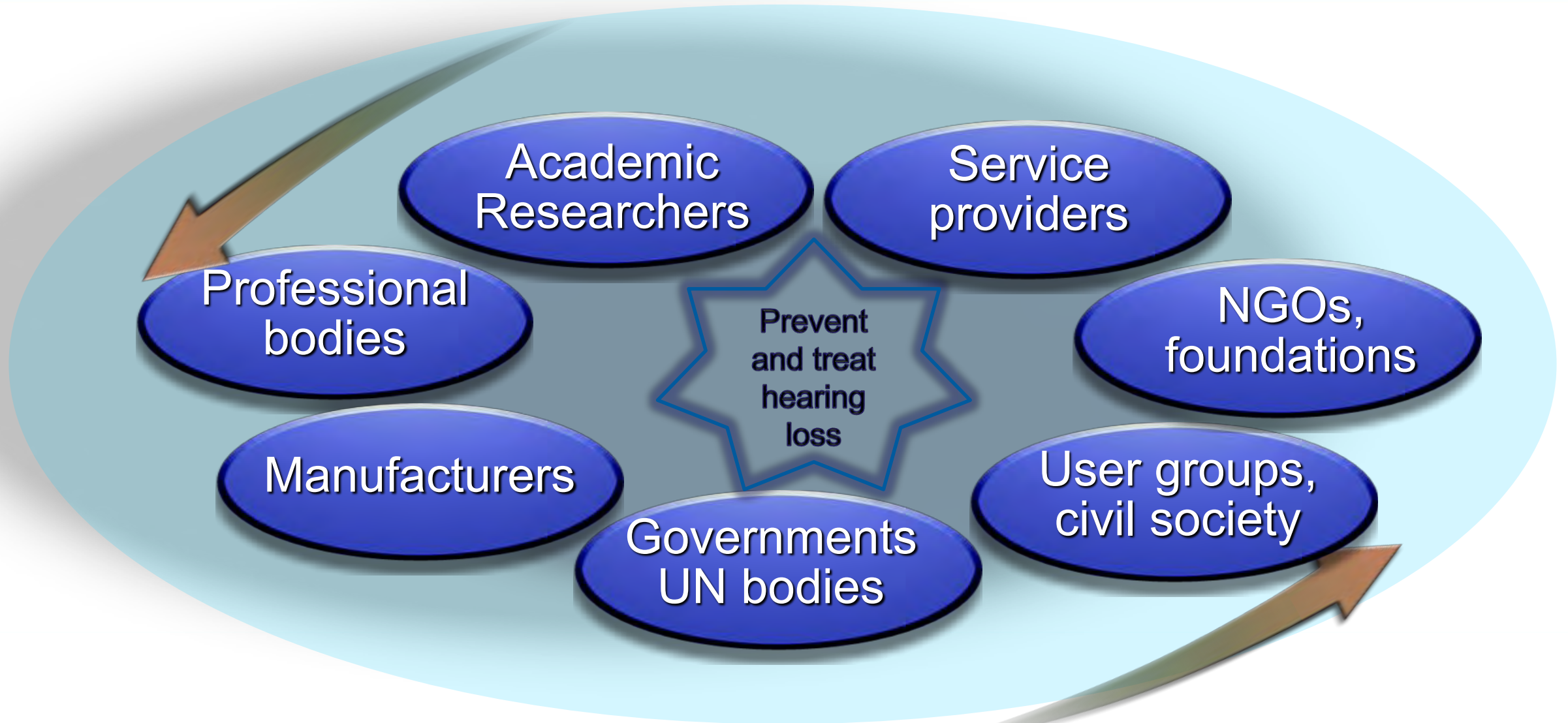
- ❑ 2015: Make Listening Safe
- ❑ 2016: Childhood hearing loss: act now, here is how!
- ❑ 2017: Action for hearing loss: make a sound investment
- ❑ 2018: To be determined

➤ **Join the global movement to create greater awareness**  
#worldhearingday





# Be a Part of the Global Movement





# Vision

**A world in which no one experiences hearing loss due to preventable causes and those with unavoidable hearing loss can reach their full potential through rehabilitation, education, and empowerment.**