It’s Loud Out There:
Hearing Health across the Lifespan

Accessible version: https://youtu.be/B7XOx4j_rf0
Hearing Loss: Poorly Recognized but Often Preventable

John Eichwald, MA
Lead Health Scientist, Office of Science
National Center for Environmental Health
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)
“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.”

Audio files courtesy of NIOSH
Simulation of Hearing Loss: Moderate Hearing Loss

Moderate Hearing Loss

“—en the —unlight— -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

Audio files courtesy of NIOSH
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

www.cdc.gov/vitalsigns/hearingloss/index.html
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.

HL: Hearing loss

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)

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

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

www.dangerousdecibels.org/education/information-center/decibel-exposure-time-guidelines/
Noise Risks: Level + Time

Continuous dB | Permissible Exposure Time
---|---
85 dB | 8 Hours
88 dB | 4 hours
91 dB | 2 hours
94 dB | 1 hour
97 dB | 30 minutes
100 dB | 15 minutes
103 dB | 7.5 minutes
106 dB | 3.75 minutes (< 4 min)
109 dB | 1.875 minutes (< 2 min)
112 dB | .9375 min (~ 1 min)
115 dB | .46875 min (~ 30 sec)

www.dangerousdecibels.org/education/information-center/decibel-exposure-time-guidelines/
## Noise Exposure Associated with No Risk of Hearing Loss

<table>
<thead>
<tr>
<th>Decibels (A-weighted)</th>
<th>Allowable Duration (hours / minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 dBA</td>
<td>24 hours</td>
</tr>
<tr>
<td>75 dBA</td>
<td>8 hours (480 minutes)</td>
</tr>
<tr>
<td>85 dBA</td>
<td>47 minutes</td>
</tr>
<tr>
<td>95 dBA</td>
<td>4.5 minutes</td>
</tr>
<tr>
<td>105 dBA</td>
<td>0.5 minutes</td>
</tr>
<tr>
<td>115 dBA</td>
<td>0 minutes</td>
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</tbody>
</table>

Integrated with equal energy rule: 3 dB exchange rate; 40-year exposure lifetime

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High-Level Impulse Noise: Risk of Immediate Hearing Damage

- **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**

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SPL: Sound pressure level
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

<table>
<thead>
<tr>
<th>DATA YEAR</th>
<th>DATA SOURCE</th>
<th>MALES</th>
<th>FEMALES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1943</td>
<td>Baltimore Maryland High School</td>
<td>15%</td>
<td>5%</td>
</tr>
<tr>
<td>1988–1994</td>
<td>NHANES</td>
<td>20%</td>
<td>12%</td>
</tr>
<tr>
<td>2005–2006</td>
<td>NHANES</td>
<td>17%</td>
<td>17%</td>
</tr>
</tbody>
</table>

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

NHANES: National Health and Nutrition Examination Survey
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**

References:

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.*

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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


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


Developed with grant support from CDC
Dangerous Decibels® Resources

Web-based games and activities

Jolene: educational manikin measures music listening levels


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)

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

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Damaged Outer/Inner Hair cells

Occupational Hearing Loss Prevalence Varies Between 12–25%
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)

OSHA: Occupational Safety and Health Administration
NHANES: National Health and Nutrition Examination Survey
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
Hierarchy of Controls

- **Elimination**: Physically remove hazard
- **Substitution**: Replace the hazard
- **Engineering Controls**: Isolate people from the hazard
- **Administrative Controls**: Change the way people work
- **PPE**: Protect the worker with personal protective equipment

Most effective (top) to least effective (bottom)
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

www.cdc.gov/niosh/topics/buyquiet/default.html
www.cdc.gov/niosh-sound-vibration/
**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

OSHA: Occupational Safety and Health Administration
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

www.safeinsound.us
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

www.safeinsound.us/archive.html#utc
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

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?

360 million live with disabling hearing loss


People affected in millions


42 120 278 360

www.who.int/pbd/deafness/estimates/en/
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

www.who.int/pbd/deafness/estimates/en/
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.

www.who.int/pbd/deafness/activities/MLS/en/
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

www.who.int/pbd/deafness/world-hearing-day/WHD2017Brochure.pdf?ua=1
apps.who.int/iris/bitstream/10665/254659/1/9789241512046-eng.pdf?ua=1

$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:
- Individual’s ongoing exposures to risk and protective factors
- Genetic risk or resilience
- Co-morbidities
- Lifestyle
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**
Public health approach is a population-based approach.

Address Hearing Loss As a Public Health Issue

Public health approach:
- Identification of needs
- Assessment of barriers
- Policy development
- Implementation, monitoring and evaluation

Clinical approach:
- Diagnosis
- Treatment
- Research

Customer Results/Benefits:
- Epidemiological surveillance
- Health promotion
- Disease prevention
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
- 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

www.who.int/pbd/deafness/activities/MLS/en/
Key Initiative: World Hearing Day, 3 March

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

www.who.int/pbd/deafness/world-hearing-day/en/
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

- Academic Researchers
- Service providers
- Professional bodies
- Manufacturers
- Governments UN bodies
- NGOs, foundations
- User groups, civil society

Prevent and treat hearing loss
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.