Ototoxic Chemicals

How Chemicals are Contributing To Hearing Loss

101 Intro Course

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TRIUMVIRATE ENVIRONMENTAL

Last Update: Sept. 2025

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By a Raise of Hands…

Who has to have a fan on or sound machine to sleep?

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How many times have you heard…

Oh! I am used to the noise!

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Why do you want to be in this seminar?

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Objectives

- Participants will be able to identify known and suspected ototoxicants.
- Participants will be able to distinguish the difference between hearing loss from noise exposures and hearing loss from ototoxicants.
- Participants will have an understanding of various control methods that can be used in the workplace.
- Participants will have an understanding of the additive and synergistic effects that both noise and ototoxicant exposures have on hearing loss.
- Participants will be able to identify the effects on Total Worker Health from ototoxicant exposures.

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Who Am I?

- EHS Director, NY/NJ Region – Triumvirate Environmental
- UH-60 Black Hawk Air Ambulance Crew Chief – Delaware National Guard (retired)
- 13 years in Occupational Safety
- Education and Credentials
  - MS – Occupational Safety & Health/Environmental Management
  - BA – Emergency and Disaster Management
  - Certified Safety Professional
  - Registered Environmental Professional

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So why am I talking

I have absorbed A LOT of Jet Fuel.

I have first-hand knowledge of these exposures and the health problems that ensue.

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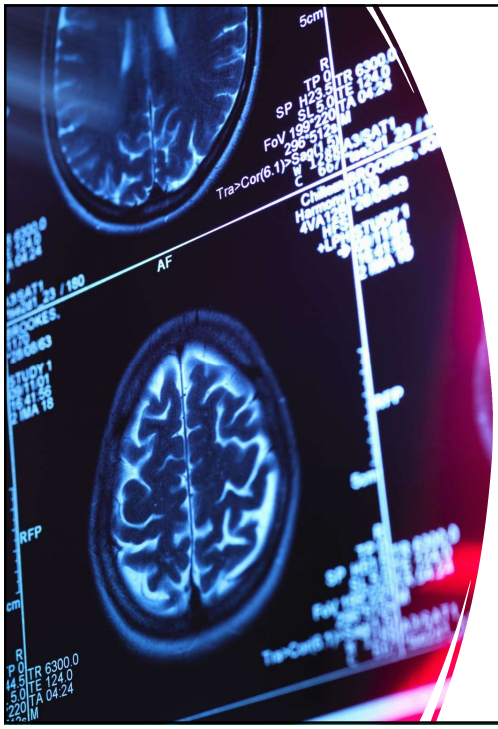

What are Ototoxic Chemicals?

- Chemicals that cause hearing loss in the absence of noise exposures.
- All routes of exposures can cause damage.
- Chemical exposures without noise exposures can cause temporary or permanent damage to various parts of the ear.
- Exposure with noise exposures can cause additive or synergistic damage to the ear.

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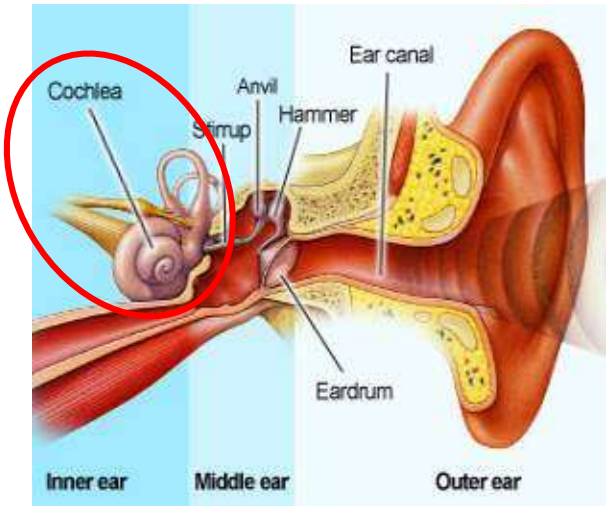
Noise Induced Ear Damage Recap

- Damage from noise occurs in the cochlea.
- There are tiny hair cells in this part of the ear that flatten out when exposed to noise.
- If the exposure is short, the hair cells raise back up.
- If the exposure is long or extremely loud, the hair cells don't recover, and hearing ability is reduced.
- People who say they are "used to the noise" are actually experiencing hearing loss.



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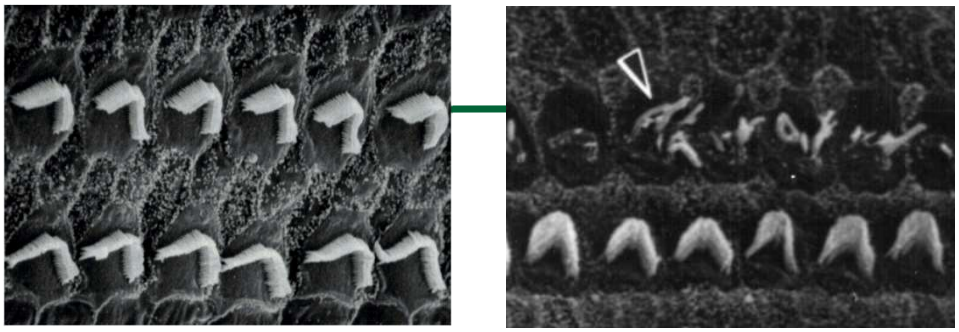
Noise Damage Effects

Hair cells in inner ear transmit noise signals to the brain.



Normal Hair Cells

Noise-damaged Hair Cells

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Some Ototoxic Chemicals

Toluene	Styrene	Xylene	Perchloroethylene	Carbon Monoxide
Carbon Disulfide	Mercury	Lead Compounds	Hydrogen Cyanide	Diesel Fuel
Kerosene Fuels	Jet Fuels	Trichloroethylene	Organophosphate Pesticides	Chemical Warfare Nerve Agents

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Ototoxic Medications

Temporary Damage	Permanent Damage
• Non-Steroidal anti-inflammatory drugs (NSAIDs) – Aspirin, ibuprofen, and naproxen in high doses or over long periods of time. • Antimalarial Quinine – large doses. • Loop diuretics (used to treat hypertension and edema)	• Certain antibiotics – Aminoglycosides (Streptomycin, neomycin, etc.) • Certain anticancer drugs – Cisplatin, in particular, is known to cause severe, permanent hearing loss.

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Chemically Induced Hearing Loss

Classified based on what they damage:

- **Neurotoxins** – damage to the nerve fibers that interfere with hearing and balance.
- **Cochleotoxicants** – affects the cochlear hair cells, which are the sensory receptors, and can impair the ability to hear.
- **Vestibulotoxicants** – affect the hair cells on the spatial orientation and balance organs.

Symptoms

Mild to severe hearing loss in one or both ears
Tinnitus – ringing in the ears
Loss of balance
Dizziness

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Additive & Synergistic effects

Still undefined for ototoxic chemicals.

Almost every case study showed evidence of additive effects.

Some case studies state that employees exposed to both noise and ototoxic chemical exposures had much more significant threshold shifts than either alone.

- 2+2=4; 2+2+2=6; 2+2+2+2=8
- 2+2=10; 2+2+2=15; 2+2+2+2=20
- Pick Your Combination
  - Work Noise + Home Noise
  - Work Chemical + Work Noise
  - Home Chemical + Work Noise
  - Home Chemical + Work Chemical + Work Noise
  - Home and Work Chemical + Home and Work Noise

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Speech discrimination dysfunction

- Some chemicals can affect the central portions of the auditory system (nerves or nuclei in the CNS, pathways to the brain, or the brain itself), not only do sounds need to be louder to be detected, but they also lose clarity.
- **Speech discrimination dysfunction** - the ability to hear voices separately from background noise, may occur and involve:
  - Compressed loudness – sound distortion
  - Frequency resolution – the inability to differentiate two sounds with similar frequency
  - Temporal resolution – the inability to detect time gaps between sounds
  - Spatial resolution – the inability to localize sound

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The downward spiral

Exposures to these chemicals and medications may cause adverse effects on hearing thresholds.

These effects can be temporary or permanent.

Hearing loss occurs in workers who do not normally participate in hearing conservation programs.

Chemically induced hearing loss can skew audiograms for workers who do participate in hearing conservation programs.

Workplace controls could be misdirected or focused on the wrong hazards.

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Total Worker Health

Hearing loss, whether temporary or permanent, has a significant impact on worker health both at work and at home.

Hearing difficulties in the workplace can cause unsafe conditions due to communication difficulties.

Hearing loss symptoms can contribute to poor sleep and mental health issues.

Hearing loss could affect future job acceptance and performance.

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Exposure Limits

No current established limit by OSHA, NIOSH, or ACGIH

ACGIH has included an OTO notation in their TLVs and BEIs publication starting in 2019:

"the potential for a chemical to cause hearing impairment alone or in combination with noise, even below 85dBA"

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Recently Updated Guidance

- NIOSH now has an Ototoxic Chemical Landing Page updated in 2024.
- ACGIH is starting to include ototoxicity notations with chemicals as new data becomes available.
- Exposure guidance could be a factor of noise exposures or simply new hard limits regardless of noise exposures.
- Many journal case studies are already recommending exposure limits to be reduced by 50% or more of current limits.

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Literature Review

- Exposure to lead, mercury, styrene, and toluene and hearing impairment: evaluation of dose-response relationship, regulations, and controls. Ehsan Hemmativaghef – Nov/Dec 2020 issue of *Journal of Occupational and Environmental Hygiene*.
- Evidence to suggest lead, mercury, styrene, and toluene all cause otological damage.
- Suggested a new Lead Biological Exposure Index of 2µg/dL, current level is 20µg/dL.
- Not enough evidence yet to determine NOAEL/LOAEL for mercury, styrene, and toluene.

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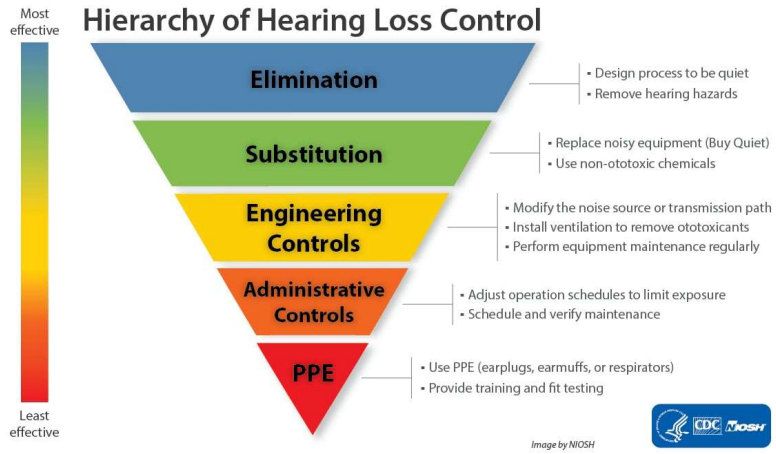
NIOSH Hierarchy of Controls



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Workplace Hazards

Speech discrimination dysfunction can also make working in noisy environments difficult and increase the risk of workplace injuries due to an inability to hear co-workers, environmental sounds, and warning signs.

Ototoxicant induced hearing loss may go unrecognized since the measure for hearing loss does not indicate the cause.

Hearing loss can be even greater with exposure to both ototoxic chemicals and noise than either hazard alone.

The lowest observed effect level (LOEAL) and no observed effect level (NOEAL) have only been identified in animals for a few substances.

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Controls

Identifying ototoxic chemicals in the workplace.

- Replacing such chemicals if possible.
- Increase engineering controls.
- Change or eliminate tasks that cause both noise and ototoxicant exposures.

Include workers exposed to ototoxicant levels in a hearing conservation program (>20% TLV).

- Some substances are expected to cause damage well below PELs.

Use lowest exposure level (usually ACGIH) for exposures to ototoxicants.

Incorporate airborne exposure monitoring in HCP.

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What we can do as Safety Professionals

- **Exposures do not have to occur at the exact same time.**
  - Evaluate the potential for noise and chemical exposures over days and weeks instead of the traditional 8-hour workday.
  - Consider at home exposures as well – employees may only be exposed to ototoxic chemical exposures at work but go home and use power tools and lawn equipment or vise-versa.
  - Consider awareness training on ototoxic chemical exposures.
- **Recommend implementing lower action levels and allowable exposure limits in the workplace.**
  - 20-50% of ACGIH's TLVs.
  - Updating HCPs to include ototoxic chemical exposure guidance.
  - Implementing HCPs in absence of noise exposures.
  - Including employees in existing HCPs who are exposed to ototoxic chemicals.

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Available Resources

- OSHA, CDC, AIHA, ACGIH, and PubMed all have resources and articles
- ACGIH Documentation on Audible Sound
- ACGIH TLV & BEI Guide
- Google – “Ototoxic Chemical Exposures”

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Wrap Up

Chemicals can cause hearing damage without noise exposures

Exposure to ototoxic chemicals and noise can cause additive or synergistic effects

Consider incorporating employees into Hearing Conservation Program with audiometric testing.

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Q&A

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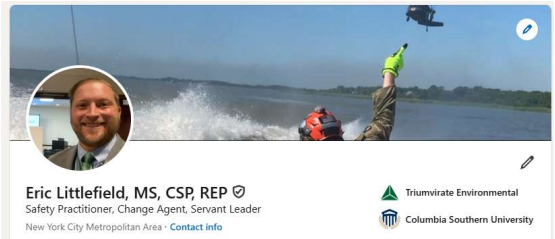

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