Noise-Induced Hearing Loss

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Noise-Induced Hearing Loss:
Outline

- Why does it matter?
- How does it occur?
- Symptoms?
- Audiometric testing
- Prevention
Causes of Deafness
(cf appendix for anatomical sites)

Sensorineural loss

Conductive loss

Hearing Loss: *Conductive loss*

- Impacted earwax;
- Ruptured eardrum (blow to head or explosion);
- Blockage of eustachian tube;
- Ossicular dysfunction:
  - Dislocation
  - Otitis media or fluid,
  - Otosclerosis
Hearing Loss: *Sensorineural loss*

- Noise
- Congenital/familial (e.g., associated with maternal rubella or flu or prenatal medication);
- Infections (e.g., measles, mumps, encephalitis, meningitis, cerebral abscess);
- Ototoxic drugs:
  - streptomycin, gentamicin, neomycin, etc.;
  - diuretics;
  - quinine, ASA
- Fracture of base of skull;
- Acoustic neuroma;
- Ménière’s disease;
- Presbycusis

Hearing Loss

- Noise-induced hearing loss - common
- Hearing loss from any cause is disabling: interferes with communications/quality of life
- may represent risks, i.e., unable to hear warnings
Noise

- Social and work related, sources of exposure including: firing of guns, playing in pop groups, listening to amplified music, etc. (cf appendix for examples of noise levels)

- Explosive noise is more damaging than continuous noise.

Noise in the Workplace

- Industries with high #s of exposed workers:
  - mining
  - construction
  - manufacturing
Noise Exposure at Work:

- 3 million in Canada exposed to hazardous noise on the job;
- > 1 million in Ontario;
  - 10-20% of Ontario workforce at risk of NIHL

What is Noise?

- Definition: unwanted sound
  - ie unpleasant, interfering or harmful
  - occupational noise: relates to excessive sound and potential harmful effects on human auditory system
- Basic parameters of noise
  - Frequency: Hertz (Hz) or cps; 20-20,000 Hz
  - Sound pressure: amplitude of sound pressure wave
Noise Induced Hearing Loss

- 100% preventable; insidious onset
- Once acquired, hearing loss is permanent and irreversible
- Can be acquired from work, home (e.g., power tools), recreation (loud music, guns, snowmobiles)

Noise (Cont’d)

- Hearing damage is related to the total noise dose received at the ear – a product of the noise level and its duration.
- Unprotected exposure to (100 dB×15 minutes) = 8 hours of exposure at 85 dB
Hazardous Noise Levels

- 90 dB(A): experienced daily x 40 years ⇒ 50% chance of 30 dB hearing loss
- 3 dB “exchange rate” or “trading ratio” = equal energy rule:
  - 3 dB increase in exposure ⇒ halving allowed exposure time
    - 85 dB(A) permitted for 8 hr
    - 88 dB(A) - for 4 hr
    - 91 dB(A): - for 2 hr

General Estimates of Work Related Noise

FOR MORE INFO...
National Institute for Occupational Safety and Health (NIOSH)
www.cdc.gov/niosh
Effects of Noise

- 2nd most common sensorineural hearing loss, after presbycusis
- Sounds exert shearing force of cilia of hear cells lining basilar membrane of cochlea
  - when excessive ⇒ metabolic overload, cellular damage and death
  - damaged cochlea cannot be repaired
  - once removed from damaging noise, no further progression of NIHL

This is your ear.

This is your ear on noise.

Any questions?
Effects of Noise on Hearing

- **Temporary threshold shift (TTS)**
  - temporary hearing decrease following noise exposure: resolves gradually after removal from noise

- **Permanent threshold shift (PTS)**
  - irreversible hearing decrease following high or repeated exposure

Noise Induced Hearing Loss

- Characterized by insidious onset:
  - Gradual loss of clarity in perceived speech, often attributed to inattention or to others not speaking clearly;
  - difficulty in hearing high-frequency sounds of speech (consonants s,f,k,t,sh)
  - Difficulty in understanding others in a crowd, often presumed to be due to competition with background noise.
  - High pitch tinnitus, initially intermittent, becomes continuous in up to 20% of cases, and can be a presenting symptom.
Prevention

- Screening questions for excessive noise exposure during routine exam/health maintenance visits:
  - “Are you exposed to excessive noise in your workplace or through music or hobbies?”
  - “Do you often have to shout to hear someone at arm’s length because it’s so noisy around you?”

Prevention

- Screening questions for excessive noise exposure during routine exam/health maintenance visits:
  - Ask about specific sources of noise
  - Ask about hearing protection: “how often do you use earplugs, earmuffs, etc?”
Prevention (Cont’d)

A general rule of thumb is: if you need to shout to communicate effectively with someone within three feet, or if after noise exposure your ears feel blocked, or you experience temporary tinnitus, the noise is harmful.

Hearing Impairment Questions:

- “Do you have any difficulty with understanding speech in noisy environments?”
- “Is your hearing not as good as it was 10 years ago?”
- “Have family members noticed a problem with your hearing?”
Audiometric Testing

- Hearing loss: measured by determining auditory threshold (sensitivity) at various frequencies
- No loud noise exposure for at least 16 hours prior to test, to avoid temporary lowering of hearing threshold.
- Learning effect up to 10-15 dB means that the second ear may test better than the first, or that the second hearing test may be better than the first one.

A Few Pointers on Interpreting Audiometric Testing

- A loss of less than 20 dB in all frequencies can be considered normal.
- A similar reduction in all frequencies or one where the threshold improves in the higher frequencies = conductive loss.
- A notch in the region of 1-3 kHz = familial cause of hearing loss.
- Presbycusis produces a smooth pattern of increasing loss in higher frequencies; these changes increase progressively.
Audiometric Characteristics of Noise Induced Hearing Loss

- Bilateral notch in hearing threshold at 3, 4, or 6 kHz with recovery of 8 kHz (classic occurs at 4 kHz);
- Progressive deepening and widening of notch with increasing exposure to noise;
- Notch due to shooting is narrow and asymmetrical (in right handed people, it is deeper on left side because right ear is protected by gun stock);
- Action levels: worsening of 10 dB(A) at 2,3,4 Hz vs baseline - worker should be notified.

Diagnosis of NIHL

- Typical pattern of NIHL on audiometry
- History of noise exposure
- Absence of other conditions causing hearing loss
  - major diagnostic problems:
    • hearing loss associated with presbycusis or ototoxic agents
    • determining degree of impairment due to aging
Hearing Loss Among Male Carpenters as a Function of Age

The Average 25 Year Old Carpenter Has 50 Year Old Ears!

- 25 Year Old Carpenter
- 50 Year Old No Noise Exposure
- 55 Year Old Carpenter

Frequency (Hz)

Hearing Level (Decibels)

Threshold for normal hearing
Etiological paradigm of hearing loss in an industrial population

- **Occupational factors:**
  - noise
  - vibration + noise
  - industrial ototoxic exp (eg solvents)
  - industrial head injury/acoustic trauma

- **Extra-occup factors:**
  - age
  - extra-occupational noise
  - disease
  - ototoxic drugs
  - non-occupational trauma
Presbycusis

- Literally means “old man’s hearing”
  - eardrum loses its elasticity and the joints of the ossicular bones stiffen
- affects as many as 60% of people over 65
- affects basically all over 80

Hearing by Age

![Hearing Loss Graph](image)

- 40 Y.O.
- 50 Y.O.
- 60 Y.O.

normal hearing
Hearing Levels in 60 Year Old Males as a Function of Noise Exposure

Prevention of NIHL:

- Engineering control
- Ear protectors (sounds attenuated to about 80 decibels - more would be associated with social isolation).
  
  Protection must be used continuously.
Prevention of NIHL

- When workers are or may be exposed to noise above 85 dB, employers must:
  - Measure the daily noise exposure
  - Identify significant sources of noise
  - Change the equipment to reduce noise (eg absorbent materials on walls or ceilings)
  - Implement hearing conservation program
  - Provide hearing protection

Prevention of NIHL

- Two main types of hearing protection: earplugs and earmuffs (follow CSA Standard Z94.2-94, Hearing protectors)
Prevention of NIHL

- If using earmuffs:
  - Replace muffs when hard or cracked
  - Keep them clean with mild soap and water

- If using earplugs:
  - Plug must make good seal in ear canal
  - Discard compressible plugs at end of work shift
  - Wash reusable earplug once a week with mild soap and water

People have MANY reasons for not using hearing protectors. (AKA: You can lead a person to hearing protectors, but you can’t get him/her to wear them.)

THE FOUR C’s
- Comfort
- Convenience
- Cost
- Communications / hear important sounds

THERE ARE OVER 200 DIFFERENT HEARING PROTECTORS. EVERYONE CAN FIND A PROTECTOR THAT MEETS THEIR NEEDS. THE BEST HEARING PROTECTOR IS THE ONE THAT’S WORN!
Prevention (Cont’d)

- One should not be exposed to 110 dB for greater than 0.5 hours per day without ear protection.

- At 1,000 dBa, a reliable ear plug (premolded, formable [foam, fiberglass, silicone, etc.] or custom molded), should afford approximately 20 dB hearing protection attenuation an an ear muff approximately 30 dB. When used together, they provide up to 40 dB attenuation.

Effect of inconsistent use of hearing protection on the amount of effective noise reduction
Available protection vs. the amount of protection obtained by untrained workers.

Factors Affecting Behavioral Change:

Individual Level
- Knowledge/beliefs
- Attitudes/values
- Stage of change
- Decisional balance
- Self-efficacy

Organizational Level
- Norms- safety culture
- Union and management priorities
- Training
- Environmental support
Does this touchy-feely stuff work?
You bet it does!

Wise-Ears Web Links

www.nih.gov/nidcd/health/wise/
www.cdc.gov/niosh/noise
www.aearo.com
www/howardleight.com
www.hearnet.com
www.hearingconservation.org
Appendix:

External Ear: causes of deafness

- Wax or foreign body in the canal
- Swelling of canal (inflammation or infection)
Middle Ear

- Significant scarring or perforation of drum
- Eustachian tube dysfunction
- Infections (e.g. otitis media)
- Dislocations or adhesions of ossicular chain
- Otosclerosis (staples immobilized in oval window).

Inner Ear

- Noise
- Presbycusis
- Heredity
- Ototoxic drugs
- Infections (e.g. meningitis)
- Ménière’s disease
- Trauma
Cranial Nerve VIII and Central Auditory Pathways

- Presbycusis
- Trauma
- Infections
- Ototoxic drugs
- Tumors

Common Sounds

<table>
<thead>
<tr>
<th>Common Sounds</th>
<th>Decibel Level</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countryside with rustling leaves</td>
<td>20-50 dBa</td>
<td>Peaceful and quiet</td>
</tr>
<tr>
<td>Normal conversation</td>
<td>50-70 dBa</td>
<td>Comfortable</td>
</tr>
</tbody>
</table>
### Common Sounds (Cont’d)

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<thead>
<tr>
<th>Common Sounds</th>
<th>Decibel Level</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>City traffic</td>
<td>70-80 dBa</td>
<td>Intrusive</td>
</tr>
<tr>
<td>Hair dryer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside car</td>
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</table>

This kind of noise makes it hard to hear someone when you are talking on the telephone.

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<th>Decibel Level</th>
<th>Effect</th>
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<tbody>
<tr>
<td>Lawnmowers</td>
<td>75-90 dBa</td>
<td>Annoying</td>
</tr>
<tr>
<td>Subway</td>
<td></td>
<td></td>
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<tr>
<td>Busy restaurant or kitchen</td>
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</tbody>
</table>

This kind of noise makes it hard to carry on a conversation. You can have hearing damage from this level of noise over time.
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<th>Common Sounds</th>
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<th>Effect</th>
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<tr>
<td>Power tools</td>
<td>90-100 dBa</td>
<td>Very Annoying</td>
</tr>
<tr>
<td>Walkman</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorcycles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snowmobiles</td>
<td></td>
<td></td>
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<tr>
<td>Manufacturing</td>
<td></td>
<td></td>
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<tr>
<td>plant hydraulic press, punch press</td>
<td></td>
<td></td>
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<tr>
<td>Pneumatic drill</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>90-100 dBa</strong></td>
<td><strong>Very Annoying</strong></td>
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**Effect:** At this level, your hearing is being damaged.

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<th>Effect</th>
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<tr>
<td>Chain saw</td>
<td>100-120 dBa</td>
<td>Being exposed to this kind of noise for more than 1 minute exposes you to hearing damage.</td>
</tr>
<tr>
<td>Air gun</td>
<td></td>
<td></td>
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<tr>
<td>Boiler room</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandblasting</td>
<td></td>
<td></td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>100-120 dBa</strong></td>
<td><strong>Being exposed to this kind of noise for more than 1 minute exposes you to hearing damage.</strong></td>
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**Effect:** Being exposed to this kind of noise for more than 1 minute exposes you to hearing damage.
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<td>Jet takeoff</td>
<td>120-140 dBa</td>
<td>At this level of noise, you reach the upper limit of pain to the ear.</td>
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<tr>
<td>Gun shot</td>
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