Preventing "Premature Aging" of Young Ears from Noise

Prevent "Premature Aging" of Young Ears from Noise

Brian Fligor, ScD, PASC
Chief Audiology Officer, Lantos Technologies, Inc.
President, Boston Audiology Consultants and Musicians’ Hearing Program
Adjunct Instructor, Northeastern University, Salus University
brian.fligor@gmail.com

Topics to Discuss

- Thought experiments regarding NIHL as a proxy for age-related HL
- Evidence of a Misspent Youth
- Epidemiology of NIHL and Tinnitus
- Activities involving high sound exposures
- The biology of NIHL/cochlear injury
- NIHL assessment, the audiogram and beyond the audiogram
- NIHL prevention, intervention, and treatment
- Can I just take a pill? Pharmacologic management of tinnitus in kids
- Evaluation, fitting, and performance of HPDs

FREQUENCY IN HERTZ (Hz)

<table>
<thead>
<tr>
<th>FREQUENCY IN HERTZ (Hz)</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEARING LEVEL (HL) IN DECIBELS (dB)</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
</tr>
<tr>
<td>50th %</td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 30 to 60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Aging&quot; ear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANSI S3.44: Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average Hearing Level ANSI S3.44 Annex B Unscreened population
Preventing "Premature Aging" of Young Ears from Noise Web Seminar
Recorded August 6, 2014

Predicted NIPTS from 2 hour daily exposure to 90% iPod level for 10 years, ANSI S3.44

- 0.9 Fractile
- 0.5 Fractile
- 0.1 Fractile

Predicted NIPTS from 4 hour daily exposure to 90% iPod level for 10 years, ANSI S3.44 Annex B

- 0.9 Fractile
- 0.5 Fractile
- 0.1 Fractile
Risk for Music Induced Hearing Loss

- Limit listening level to 60% of max
- Limit listening time to 1 hour
- Because in-ear earphones were 7.9 dB higher than over-the-ear at the same gain setting, shorter time or lower level is necessary


Noise-Induced Hearing Loss

Gradual Noise-Induced Permanent Threshold Shift (NIPTS)
- 78 dBA – 130 something (?) dBA
- Outer hair cells
- Metabolic overload after duration of exposure
- Gradual loss in sensory hearing
- NITTS: recovery after a rest period

Acoustic Trauma (AT)
- 140 dB Peak SPL (132 dB SPL - Price, 1981)
- Usually from impulse: brief, fast rise time
- Can result from marked “overdose”
- Mechanical Damage after single exposure
- Immediate loss of sensory hearing
Noise (chronic exposure) and drug-induced SNHL: common pathway
Shared pathophysiology: apoptotic death of (initially) OHC from metabolic dysfunction
- Dose-effect relationship
- Cumulative through lifetime
- Genetic predisposition
- Similar insidious impact on speech intelligibility
- Concomitant tinnitus (and hyperacusis?)

Mechanisms of Ototoxicity
Oxidative stress:
- Reactive Oxygen Species (ROS): 98% of oxygen used in the ear is to convert ADP into ATP, 2% into super oxide (highly reactive molecule, unpaired electron)
- Pathologic process, 7-fold increase in ROS production
- Cascade of events leading to "programmed" cell death of OHC
  = apoptosis

Injury from Chronic Noise Exposure:
- \( F(\text{time & intensity}) \)
- \( F(\text{frequency}) \) – A-weighting "network"

NIPTS (also NITTS):
Hearing threshold decrease poorest in the 3000 – 6000 Hz range (4000 Hz Notch)
Other injuries in NIHD:
- tinnitus
- abnormal pitch perception (diploacusis)
- loudness intolerance (hyperacusis)
Impact of Ototoxicity in Children: Accelerated Ear-Age?

ANSI S3.44 (1996): Expected hearing thresholds as a function of age (years)

\[ H_{18} = \alpha (Y-18)^2 \]

Where:
- \( H_{18} \) = hearing as a function of age, re: an 18-year-old of same gender
- \( \alpha \) = a constant based on the frequency (Hz) and gender (table in ANSI S3.44, 1996)
- \( Y \) = age (years)

Johnson (1988) suggested solving for \( Y \) to describe age-equivalent hearing shift in years:

\[ Y = \sqrt[3]{\frac{H_{18}}{\alpha}} \] ("18" dropped, all subjects <=18 yrs)

Accelerated Ear-Age

- Ear Age (Y) = Avg Ear Age assigned to 4k, 6k, and 8k Hz post-treatment
  - Patient 1: 4 yo (EA=44 yrs); Patient 6: 18 yo (EA=51 yrs); Patient 7: 10 yo (EA=65 yrs)

Figure, Fligor et al (2012) "Accelerated ear age: a new measure of chemotherapy induced ototoxicity" Pediatric Blood and Cancer 59:947–949

Evidence for greater susceptibility in youth

Kujawa and Liberman (2006)

Acceleration of Age-Related Hearing Loss by Early Noise Exposure: Evidence of a Misspent Youth

Preventing "Premature Aging" of Young Ears from Noise Web Seminar
Recorded August 6, 2014

Kujawa and Liberman (2006)

Kujawa and Liberman (2006)

Oregon Museum of Science and Industry (OMSI): Listen Up!

<table>
<thead>
<tr>
<th></th>
<th>Young Female</th>
<th>Young Male</th>
<th>Adult Female</th>
<th>Adult Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head on a stereo headbands</td>
<td>15%</td>
<td>25%</td>
<td>55%</td>
<td>70%</td>
</tr>
<tr>
<td>Ride a go-kart or power scooter</td>
<td>34%</td>
<td>56%</td>
<td>33%</td>
<td>72%</td>
</tr>
<tr>
<td>Drive on a private road, motorcycle, or delivery truck</td>
<td>32%</td>
<td>37%</td>
<td>19%</td>
<td>41%</td>
</tr>
<tr>
<td>Fired a gun</td>
<td>24%</td>
<td>40%</td>
<td>16%</td>
<td>49%</td>
</tr>
<tr>
<td>Ride in a car with a loud stereo</td>
<td>75%</td>
<td>66%</td>
<td>71%</td>
<td>72%</td>
</tr>
<tr>
<td>Played in loud</td>
<td>22%</td>
<td>22%</td>
<td>71%</td>
<td>33%</td>
</tr>
<tr>
<td>Went to a motorcycle or car race</td>
<td>22%</td>
<td>22%</td>
<td>13%</td>
<td>26%</td>
</tr>
<tr>
<td>Went to a concert</td>
<td>50%</td>
<td>42%</td>
<td>54%</td>
<td>52%</td>
</tr>
<tr>
<td>Went to a batting gal or concert truck show</td>
<td>15%</td>
<td>18%</td>
<td>10%</td>
<td>36%</td>
</tr>
</tbody>
</table>
Dangerous Decibels, OMSI: Listen Up!

Youth group: 10% had > 30 dB HL at 4k Hz
- 9% of the boys (6,400)
- 10% of the girls (9,700)

Adult group: 12% had > 30 dB HL at 4k Hz
- 16% of the men (8,700)
- 9% of the women (12,000)

http://www.dangerousdecibels.org/research/omsi-research-data/
Preventing "Premature Aging" of Young Ears from Noise Web Seminar
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14-year-old male (seen 1/09)
Did not pass school hearing screen 1 month prior, iPhone user

DPOAEs, 14-year-old iPod users (1 ½ years), notched audiogram

- Reduced or absent DPOAEs at frequencies 4000 Hz and above re: 95% normals (Gorga, et al., 1997)

Why a notch at 4000 Hz?
Combination of ear canal acoustics, anatomy, and cochlear blood supply
- REUG/TFOE
- Humans: the region of maximum damage is ½ to 1 octave above frequency of maximum stimulation (different in other mammals, cochlear turn)
- Poorer blood supply in basal region than in apical region
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Transfer Function of the Open Ear

The “80-90 Rule” for using MP3 players


Teenagers and Earphones

Portnuff, Fligor & Arehart (2011)
Preventing "Premature Aging" of Young Ears from Noise Web Seminar
Recorded August 6, 2014

Teenager’s PLD Noise Exposure

- Portnuff et al (2011):
  - Average listening time: 2 hours
  - Estimated CLL: 74.09 dBA (52.3 - 91.8 dBA, SD 10.8 dBA)

<table>
<thead>
<tr>
<th>OSHA</th>
<th>NIOSH</th>
<th>EU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Noise Dose</td>
<td>8.0%</td>
<td>20.9%</td>
</tr>
<tr>
<td>Noise Dose Range</td>
<td>0.74.1%</td>
<td>0.241.0%</td>
</tr>
</tbody>
</table>

Subjects exceeding:

- 50% Noise Dose: 1 (1.4%) | 4 (13.8%) | 7 (24.1%)
- 100% Noise Dose: 0 (0%) | 2 (6.9%) | 4 (13.8%)

Social identity and PLD use

<table>
<thead>
<tr>
<th>Ethnicity/Race</th>
<th>% Exceeds Max Daily Noise Dose</th>
<th>% Exceeds Max Weekly Noise Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>African</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>African American</td>
<td>86%*</td>
<td>86%**</td>
</tr>
<tr>
<td>Asian</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>Caribbean</td>
<td>69%</td>
<td>46%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>65%</td>
<td>65%</td>
</tr>
<tr>
<td>White</td>
<td>37%</td>
<td>34%</td>
</tr>
</tbody>
</table>

*p = 0.004; **p = 0.002

Fligor, Levey & Levey (2014)

Social identity and PLD use

<table>
<thead>
<tr>
<th>Age</th>
<th>% Exceeds Max Daily Noise Dose</th>
<th>% Exceeds Max Weekly Noise Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-24 years</td>
<td>68%*</td>
<td>65%**</td>
</tr>
<tr>
<td>25-56 years</td>
<td>48%</td>
<td>41%</td>
</tr>
</tbody>
</table>

*p = 0.015; **p = 0.004

Non-significant: Education, gender, NIHL-risk awareness, campus vs. Union Square, mode of transit, device-type, or music genre

Significant Factor: Social identity?

Fligor, Levey & Levey (2014)
Why not have level warning indicator?

Vastly different earphone sensitivity!

Etymotic Research, Inc.
- ER 4 = 108 dB/Volt at 1k Hz
- ER 4P = 120 dB/Volt at 1k Hz

Shure, Inc.
- SCL3 = 129 dB/Volt at 1k Hz
- SE530 (triple driver) = 133 dB/Volt at 1k Hz

Ultimate Ears
- Super Fi3 (single driver) = 134 dB/Volt at 1k Hz
- Super Fi5 EB (quadruple driver) = 139 dB/Volt at 1k Hz

Dr. Dre’s Beats™, “Kid Safe”
limited headphones

- Kid-Marketed Headphones: 93.1-94.6 dBA free-field equivalent at max
- Jewell (Not volume limited) and Jbuddies (“keeps the volume below 90 dB”)

- Beats™ over-the-ear: 97.3 dBA free-field equivalent at max
- Beats™ earbud: 101.9 dBA free-field equivalent at max

Acceptable strategy with PLD?
Sound isolation and comfort: custom vs. non-custom

Used with permission by Sensaphonics
Epidemiology of Tinnitus

- Any tinnitus: 25.3% of adults
- Frequent tinnitus: 7.9% (>25 million)

Factors increasing odds (abridged list):
- White, non-Hispanic
- > 40 years
- Smoker
- Hypertensive
- Diabetic
- Noise Exposure
- Depression/Anxiety

Epidemiology of Tinnitus

Meikle, Creedon and Griest (2007):
- Sudden or prolonged sound exposure primary factor in tinnitus occurrence

Mrena et al (2004):
- Tinnitus present after 90% of acoustic trauma

Griest and Bishop (1998):
- Tinnitus may be an early indicator of impending NIHL

Tinnitus in Children

Holgers (2003), tinnitus in 7 year olds:
- 12% experience tinnitus
- 2.5% report onset after loud sound

Coelho et al (2007), tinnitus in 5-12 year olds:
- 37.5% experience tinnitus
- 19.6% experience tinnitus "suffering"
- Noise exposure is significant risk factor

Martin et al (2011), 9-11 year olds report of tinnitus:
- "Sometimes" "often" or "always" = 47%
Elements of a Hearing Loss Prevention Program (HLPP)

Application to exposures in children
- Noise Survey (assessment)
- Engineering Controls
- Audiometric Monitoring
- Education and Motivation
- Hearing Protection Devices
Sound Exposures:
Bamboozle Road Show

<table>
<thead>
<tr>
<th>Leq (dBA)</th>
<th>Time (hrs)</th>
<th>Noise dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>4</td>
<td>67%</td>
</tr>
</tbody>
</table>

Table 1. Total audience exposure

<table>
<thead>
<tr>
<th>Leq (dBA)</th>
<th>Time (hrs)</th>
<th>Noise dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>98</td>
<td>2</td>
<td>219%</td>
</tr>
</tbody>
</table>

Table 2. Total crew exposure (4 hour show + sound check and setup)

- Leq is the typical 5-minute equivalent continuous sound level in A-weighted decibels
- CPC for determining "Noise dose" = 85 dBA for 8hr-Leq, 36dB exchange rate

Audiology Today May-June 2011: pp 30-40

How loud (and how long) is too loud (and too long)?

We thank those researchers and unprotected workers from decades ago:
- Passchier-Vermeer (1968)
- Robinson (1968, 1971)
- Baughn (1973)
- Lempert and Henderson (1973) – ONHS

ONHS 1968-1972

Scatter Plot of Noise Exposure (level and years) of 792 workers
Preventing "Premature Aging"
of Young Ears from Noise Web Seminar
Recorded August 6, 2014

Damage Risk Criteria

- OSHA PEL
  - 90 dBA
  - 5 dB

- NIOSH REL
  - 85 dBA
  - 3 dB

- EU Directive
  - 80 dBA
  - 3 dB

Exchange rate

- 90 dBA | 8 hrs
- 95 dBA | 4 hrs
- 100 dBA | 2 hrs
- 105 dBA | 1 hr

LIBERAL .................................................. CONSERVATIVE

Risk for a “Material Hearing Impairment”
8-hr TWA exposure, 40 year “working lifetime”


<table>
<thead>
<tr>
<th>Organization</th>
<th>TWA Noise Exposure</th>
<th>Estimated % at Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO</td>
<td>90 dBA</td>
<td>21%</td>
</tr>
<tr>
<td></td>
<td>85 dBA</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>80 dBA</td>
<td>0%</td>
</tr>
<tr>
<td>EPA</td>
<td>90 dBA</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>85 dBA</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>80 dBA</td>
<td>5%</td>
</tr>
<tr>
<td>NIOSH</td>
<td>90 dBA</td>
<td>29%</td>
</tr>
<tr>
<td></td>
<td>85 dBA</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>80 dBA</td>
<td>3%</td>
</tr>
<tr>
<td>Prince, et al 1997</td>
<td>85 dBA</td>
<td>8%</td>
</tr>
</tbody>
</table>

Material Hearing Impairment?

NIOSH 1998 Definition:

- > 25 dB HL AI-weighted Avg. 1k, 2k, 3k, and 4kHz
  (What’s that like?)
  - Appropriate to apply 40-year timetable to children/teenagers?
  - Is this “acceptable risk” for children/teenagers?
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FREQUENCY IN HERTZ (Hz)

HEARING LEVEL (HL) IN DECIBELS (dB)

KEY

R     L

SOUND FIELD S

"Material" Hearing Impairment
NIOSH 1998
Re: ANSI S3.44

Normal
Mhl HI

"Material" Hearing Impairment
NIOSH 1998
Re: ANSI S3.44

Normal
Mhl HI

"Material" Hearing Impairment
NIOSH 1998
Re: ANSI S3.44

Normal
Mhl HI
Car Stereos and Little Ears: a hazard?

Ramsey & Simmons (1993)
- Ten car stereos, 150 – 600 watts, user-selected levels
  - 84-108 dBA
  - Average OSHA dose = 108.5%

How to enforce?

Car Stereos and Little Ears: a hazard?

My own "experiment"
- Factory-installed stereo, new sedan
  - 276 watts, 8-speaker surround, maximum level ~90 dBA
  - Levels 3-feet outside car = 73 dBA, Peak outside car = 77 dBA
  - Noise nuisance more than danger?

Firearms exposure

<table>
<thead>
<tr>
<th>Firearm Type</th>
<th>Peak Sound Level (dB SPL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Rifle</td>
<td>140-145</td>
</tr>
<tr>
<td>Medium Rifle</td>
<td>157-160</td>
</tr>
<tr>
<td>Large Rifle</td>
<td>160-174</td>
</tr>
<tr>
<td>Shotgun</td>
<td>152-166</td>
</tr>
<tr>
<td>Small Pistol</td>
<td>150-157</td>
</tr>
<tr>
<td>Large Pistol</td>
<td>158-174</td>
</tr>
</tbody>
</table>
Firearms exposure

- The larger the bore (caliber) the higher the SPL.
- The ear toward the muzzle or rifle receives significantly higher level (head shadow).
- Exposure to a single shot, unprotected, can cause acoustic trauma.
- Levels are higher if in an enclosure (turkey blind, deer stand, indoor shooting range).
- Situation awareness necessary for safety and success when in the field (limits HPD options, and acceptance).
- Part of social identity in many parts of the U.S.

Live music: sound levels and hearing loss mitigation efforts

Avg. Concert level 103.4 dBA (Clark, 1992)
4% of concert attendees use HPD (Gilles et al, 2013)
Sound Levels at Concerts: Taylor Swift

Sound Levels at Concerts: Life is Good

Sound Levels at Concerts: LiG “Kid Stage”
Sound Levels at Concerts: LiG “Kid Stage”

After a long day at the music festival, he may be toast, but at least his ears aren’t!

Other musical pursuits
Other musical pursuits:
Berklee College of Music

- Jazz trio, 18 year old freshman

---

MIHL prevention in practice

- Live music consumers
- Live music producers/performers

---

### Levels on Stage: 500 capacity club

<table>
<thead>
<tr>
<th>Start End</th>
<th>L(A) (dB)</th>
<th>Time to 100% Dose T (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:15-8:20</td>
<td>108</td>
<td>8</td>
</tr>
<tr>
<td>8:30-8:35</td>
<td>108</td>
<td>8</td>
</tr>
<tr>
<td>8:45-8:50</td>
<td>108</td>
<td>8</td>
</tr>
<tr>
<td>8:55-9:00</td>
<td>108</td>
<td>8</td>
</tr>
<tr>
<td>9:05-9:10</td>
<td>108</td>
<td>8</td>
</tr>
<tr>
<td>9:15-9:20</td>
<td>108</td>
<td>8</td>
</tr>
<tr>
<td>9:25-9:30</td>
<td>108</td>
<td>8</td>
</tr>
<tr>
<td>9:35-9:40</td>
<td>108</td>
<td>8</td>
</tr>
<tr>
<td>9:45-9:50</td>
<td>108</td>
<td>8</td>
</tr>
<tr>
<td>9:55-10:00</td>
<td>108</td>
<td>8</td>
</tr>
</tbody>
</table>

Set Length: 15 minutes
Estimated Dose: 1394%

Total for the night: 3501%
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Hypothetical Protected Sound Exposures:
Bamboozle Road Show 2010

<table>
<thead>
<tr>
<th>Earplug</th>
<th>L1(eqA)</th>
<th>Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Musician's Earplug™</td>
<td>115</td>
<td>9</td>
</tr>
<tr>
<td>w/Safe-T</td>
<td>105</td>
<td>75</td>
</tr>
<tr>
<td>w/Er/1 (1-45)</td>
<td>110</td>
<td>75</td>
</tr>
<tr>
<td>w/Er/2 (1-45)</td>
<td>110</td>
<td>75</td>
</tr>
<tr>
<td>w/Er/3 (1-45)</td>
<td>110</td>
<td>75</td>
</tr>
</tbody>
</table>

Only valid if plug is used > 95% of exposure time

Audiology Today May-June 2011: pp 30-40

“Real Ear” Probe Microphone sound level measures
Non-Custom earplug, shallow insertion

Open: Green
Shallow Plug: Fuchsia

Non-Custom earplug, shallow insertion

Open: Blink-182

Non-Custom earplug, shallow insertion

Shallow Plug: Blink-182
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Non-Custom earplug, full insertion

Non-Custom ER20 earplug

Open: Green
ER20: Gold

Non-Custom ER20 earplug
Open: Blink-182
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Non-Custom ER20 earplug

Non-Custom ER20 earplug

Non-Custom ER20 earplug
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Levels on Stage: hypothetical if used ER 15

<table>
<thead>
<tr>
<th>Time</th>
<th>Level</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:15</td>
<td>93</td>
<td>75.6</td>
</tr>
<tr>
<td>8:30</td>
<td>93</td>
<td>75.6</td>
</tr>
<tr>
<td>8:35</td>
<td>95</td>
<td>47.6</td>
</tr>
<tr>
<td>8:45</td>
<td>93</td>
<td>75.6</td>
</tr>
<tr>
<td>8:55</td>
<td>93</td>
<td>75.6</td>
</tr>
<tr>
<td>9:00</td>
<td>94</td>
<td>60.0</td>
</tr>
<tr>
<td>9:05</td>
<td>92</td>
<td>95.2</td>
</tr>
<tr>
<td>9:10</td>
<td>93</td>
<td>75.6</td>
</tr>
<tr>
<td>9:15</td>
<td>92</td>
<td>95.2</td>
</tr>
<tr>
<td>9:20</td>
<td>94</td>
<td>60.0</td>
</tr>
<tr>
<td>9:25</td>
<td>95</td>
<td>47.6</td>
</tr>
<tr>
<td>9:30</td>
<td>93</td>
<td>75.6</td>
</tr>
<tr>
<td>9:35</td>
<td>94</td>
<td>60.0</td>
</tr>
</tbody>
</table>

Set Length 30 minutes
Estimated Dose: 43.6%
Total for the night: 109.4%

Set Length 40 minutes
Estimated Dose: 65.8%
Total for the night: 119.4%
Elements of a Hearing Loss Prevention Program (HLPP)

Five tenets of HLPP

- Noise Survey (assessment)
- Engineering Controls
- Audiometric Monitoring
- Education and Motivation
- Hearing Protection Devices

Elements of HLPP

- Audiometric Monitoring
  - Comprehensive audiometry (air, bone, speech)
  - Impedance, +/- MEMR
  - DPOAEs, 1500-10k Hz, 4 freq’s per octave
  
  At least annually, or as needed to evaluate TTS

- Additions to evaluation for tinnitus complaint:
  - Tinnitus Reaction Questionnaire (Wilson et al 1991):
  - > 17 = "clinically significant"
  - At intake and end point of therapy
  - Minimum masking level
  - +/- loudness and pitch matching
  - Informational Counseling

---

<table>
<thead>
<tr>
<th>FREQUENCY IN HERTZ (Hz)</th>
<th>HEARING LEVEL (HL) IN DECIBELS (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>10</td>
</tr>
<tr>
<td>250</td>
<td>20</td>
</tr>
<tr>
<td>500</td>
<td>30</td>
</tr>
<tr>
<td>750</td>
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</tr>
<tr>
<td>6000</td>
<td>100</td>
</tr>
<tr>
<td>8000</td>
<td>110</td>
</tr>
</tbody>
</table>

KEY

R     L
SOUND FIELD S

KEY

12 year old male
Did not pass school hearing screening
Daily use of headphones
Preventing "Premature Aging" of Young Ears from Noise Web Seminar
Recorded August 6, 2014

**FREQUENCY IN HERTZ (Hz)**

<table>
<thead>
<tr>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
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<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
</tr>
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</table>

**HEARING LEVEL (HL) IN DECIBELS (dB)**

| 0   | 10  | 20  | 30   | 40   | 50   | 60    | 70   | 80   | 90   | 100  | 110  | 120  |

**KEY**

- R     L
- S

Now 13 years old
Still uses headphones daily, but not on day of evaluation

**FREQUENCY IN HERTZ (Hz)**

<table>
<thead>
<tr>
<th>125</th>
<th>250</th>
<th>500</th>
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<td>60</td>
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</tbody>
</table>

**HEARING LEVEL (HL) IN DECIBELS (dB)**

| 0   | 10  | 20  | 30   | 40   | 50   | 60    | 70   | 80   | 90   | 100  | 110  | 120  |

**KEY**

- R     L
- S

14-year-old male (seen 1/09)
Did not pass school hearing screen 1 month ago, iPhone user

**DPOAEs, 14-year-old iPod users (1 1/2 years), notched audiogram**

- Reduced or absent DPOAEs at frequencies 4000 Hz and above re: 95% normals (Gorga, et al., 1997)
Reduced/Absent DPOAE at F2 = 8391 Hz Bilaterally
Preventing "Premature Aging" of Young Ears from Noise Web Seminar
Recorded August 6, 2014

DPOAEs, 33 year old music enthusiast/audio engineer, normal audiogram

- Reduced/Absent DPOAE at F2 = 8391 Hz Bilaterally
- Right ear has some dips below 95% of normals re: Gorga et al. (1997)

DPOAEs, 26 year old singer (10 years experience), essentially normal audiogram

- Reduced DPOAE at F2 = 3000 – 10,0031 Hz Bilaterally re: 95% normals (Gorga, et al., 1997)
Preventing "Premature Aging" of Young Ears from Noise Web Seminar
Recorded August 6, 2014

DPOAEs, 39 year old singer/guitarist (20 years experience), essentially normal audiogram
Tinnitus sufferer

- Absent DPOAEs at F2 = 6000 – 10,031 Hz Bilaterally
- Reduced DPOAEs at other discrete frequencies
  re: 95% normals (Gorga, et al., 1997)

Management of Tinnitus

Habituation of the Reaction vs.
Habituation of the Perception
Management of Tinnitus

Habituation of the Reaction vs. Habituation of the Perception

Presentations of Tinnitus

- **Transient "spontaneous" tinnitus (TST)**
- **Temporary & TTS (Temporary Threshold Shift)**
- **Chronic**
  - High-pitched ringing (tonal)
  - High-frequency hissing
  - Multi-tonal
- **Medically significant**
  - Unilateral, pulsatile, low pitched, etc

Most Frequently Reported Problems with “Bothersome” Tinnitus

- Getting to sleep
- Persistence of tinnitus (can’t escape)
- Understanding speech
- Despair, frustration, depression
- Annoyance, irritation, inability to relax
- Poor concentration or confusion
Management of Tinnitus:
Reaction Habituation in Children/Teenagers

1. It’s not their fault…
2. It’s not the tinnitus, it’s their reaction to it.
3. The tinnitus is neutral: it’s like leaky water faucet
4. Enhanced environmental sound.
5. ENSURE future exposures are less than 50% noise dose
6. Connect with a team of providers in complementary fields:
   - increased vigilance for self-destructive behaviors
   - Management begins after medical clearance: no active disease process (or medical management for active disease process has begun)

<table>
<thead>
<tr>
<th>HYPERACUSIS</th>
<th>MISOPHONIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discomfort when exposed to a sound that would not evoke a similar reaction in an average listener. Physical characteristics of the sound are the only modulating factor.</td>
<td>A “hatred of sound” modulated by the patient’s previous experience and the presentation context.</td>
</tr>
</tbody>
</table>

- Commonly concurrent with tinnitus
- Exacerbation of tinnitus is a common reason given for avoidance of loud noises or specific sounds
- May limit tinnitus intervention strategies


Can’t I just take a pill?

Maybe? For assisting in reaction to tinnitus:
- Anti-anxiety medications
  - Benzodiazepine; e.g., Clonazepam (Klonopin): Anti-anxiety (and anti-seizure)
- Anti-depression medications
  - Selective serotonin reuptake inhibitors (SSRI); e.g., Fluoxetine (Prozac; Sarafem): anti-depressant and anti-OCD
  - Careful use in children and teenagers (suicide risk)
- Close medical management by psychiatrist
Summary: NIHL “Premature” aging of young ears

- Recreational activities are often loud
  - Firearms exposure #1 cause of recreational NIHL
  - If live entertainment, competition with audience (think Beatles, Feb 11, 1964; 8000 screaming fans)
  - If PLD-headphones, competition with ambient noise (if not using sound isolating headphones)
- Damage-Risk Criteria (e.g., 85 dBA 8-hr Leq, 3-dB exchange rate)
  - based on 40-year exposures
- 40-years does not equate to a lifetime: younger start to recreational sound exposures than occupational
- What is an acceptable hearing loss risk in children?

Summary: NIHL “Premature” aging of young ears

- Acceptable hearing loss prevention is a combination of awareness (education and motivation), modest sound management (Foam plugs? Custom attenuators? Just move away? Mix with quieter entertainment?), and engagement of young people
- Finger wagging doesn’t work on teenagers in other health behaviors, why would it here?