


**Recreational Noise Induced Hearing Loss:
A Summary of the Evidence**



Brian Fligor, ScD
Director of Diagnostic Audiology
Children's Hospital Boston
Instructor in Otology and Laryngology
Harvard Medical School

Special Thank You To ...

Co-presenters in the NIHL Expert Seminar Series:
Sumit Dhar, PhD (July 13)
OAEs and Sound Exposure
Frank Wartinger, AuD (July 20)
Tinnitus Management in Audio Professionals
Greg Flamme, PhD (July 27)
NIHL Risk from Impulse Noise Exposure

Audiology Online:
Carolyn Smaka, AuD, Editor-in-Chief

- Topics to Discuss**
- ✓ The science of NIHL
 - ✓ Regulatory attempts at minimizing NIHL
 - ✓ Exposures of music consumers (noise survey)
 - ✓ The clinical evaluation of NIHL (audiometric monitoring)
 - ✓ Implications for NIHL and its prevention (hearing protection devices)

Oregon Museum of Science and Industry: *Listen Up!*

During the past year, the percentage of participants who:	Young Female	Young Male	Adult Female	Adult Male
Used stereo headphones	83%	78%	56%	59%
Used a gas-powered lawn mower or leaf blower	34%	56%	33%	73%
Rode on a jet ski, snowmobile, or motorcycle	32%	37%	19%	41%
Fired a gun	24%	40%	16%	45%
Rode in a car with a loud stereo	75%	66%	71%	73%
Played in band	22%	32%	7%	13%
Went to a motorcycle or car race	22%	26%	13%	26%
Went to a concert	50%	42%	54%	52%
Went to a tractor pull or monster truck show	15%	24%	10%	16%

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)

**Recreational NIHL Risk
*other than music***

#1 Firearms (Greg Flamme, July 27)

Firearm Type	Peak Sound Level (dB)
Small Rifle	140-145
Medium Rifle	157-160
Large Rifle	160-174
Shotgun	152-166
Small Pistol	150-157
Large Pistol	158-174

These are the levels recorded in an open field. Shortened barrel, a muzzle break, and shooting enclosure > SPL all increase the sound levels above what are shown here. Dr. Michael Stewart of Central Michigan University, and presented on July 3, 2008 on Audiology Online.

Recreational NIHL Risk
other than music

Woodworking

Woodworking tool	A-weighted decibels (dBA) at the user's ear
Minilathe with spindle	60
Drill Press	66
Spindle Sander	70
Brad Nailer	74
1-hp Dust Collector	76
6" Jointer	83
10" Cabinet Tablesaw	88
5" Random Orbit Sander	90
2-hp Air Compressor	94
14" Bandsaw	95
Biscuit Joiner	98
Router	100
Shop Vacuum	101
Miter saw	103
Benchtop Planer	105
Circular Saw	109
Chainsaw	111

Bob Hunter, WOOD Magazine July 2008, confirmed by Mark Stephenson, PhD, NIOSH.

Recreational NIHL Risk
other than music

Motor Sports, Sporting Events

- Jetskis, motorcycles, snowmobiles, ATVs
> 100 dBA

- Monster truck rally, tractor pull

- NASCAR

Rose, et al., (2008): 150 feet from the racetrack, levels were on average close to 101 dBA (range 96.5 – 104 dBA). At 20 feet from the racetrack (the front row of seating), average levels were over 106 dBA (range 99 – 109 dBA).

Recreational NIHL Risk
other than music

Fireworks

- After July 4: unilateral or asymmetric PTS

Gupta and Vishwakarma (1989):

- Fireworks sound levels at 3 meters
126 – 156 dB

- children 9 to 15 years old more likely to have permanent hearing loss from fireworks than adults

Elements of a Hearing Loss Prevention Program (HLPP)

Application to music exposure

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

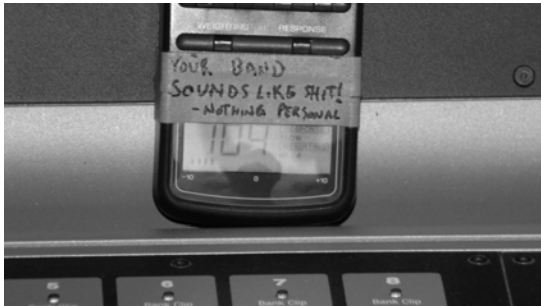
Bamboozle Road Show, June 2010



Bamboozle Road Show, June 2010



Bamboozle Road Show, June 2010



Sound Exposures: Bamboozle Road Show

Leq* (dBA)	105
Time (hrs)	4
Noise dose**	5000%

Table 1. Total audience exposure

Leq* (dBA)	99
Time (hrs)	7
Noise dose**	2198%

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

* Leq is the typical 5-minute equivalent continuous sound level in A-weighted decibels
 ** DRC for determining "Noise dose" = 85 dBA for 8-hr Leq, 3dB exchange rate

Audiology Today May/June 2011: pp 30-40

Noise-Induced Hearing Loss

Gradually Developing 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

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:

- tinnitus
- abnormal pitch perception
- loudness tolerance problems

Risk for a "Material Hearing Impairment" Max Noise Dose 85 dBA trade 3 vs. 90 dBA trade 5?

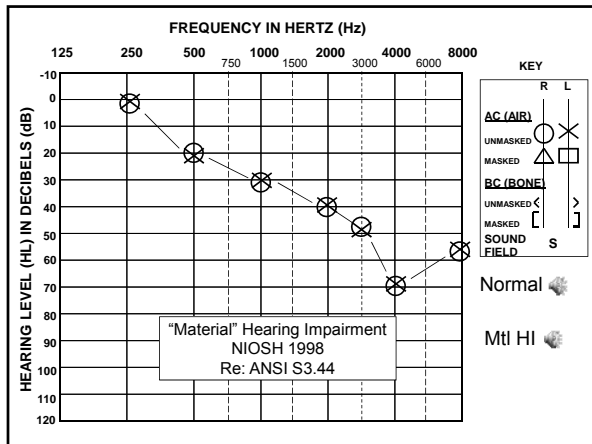
OSHA (1981): **Minimum Standard for Safety**

Organization	TWA Noise Exposure	Estimated % at Risk
ISO	90 dBA	21%
	85 dBA	10%
	80 dBA	0%
EPA	90 dBA	22%
	85 dBA	12%
	80 dBA	5%
NIOSH	90 dBA	29%
	85 dBA	15%
	80 dBA	3%
Prince, et al 1997	85 dBA	8%

Material Hearing Impairment?

NIOSH 1998 Definition:

> 25 dB HL Avg. 1k, 2k, 3k, and 4kHz
 (What's that like?)



Book Chapters on MIHL (and other) Risk

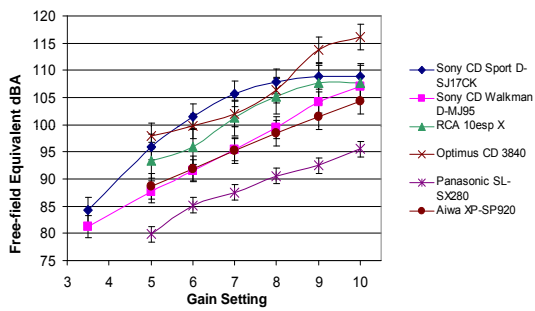
Hearing Loss in Musicians:
Prevention and Management
March 2009, Plural Publishing
Ed. Marshall Chasin, Au.D.



Consumer Handbook on
Hearing Loss and Noise
April 2010, Auricle Ink Publishers
Ed. Marshall Chasin, Au.D.

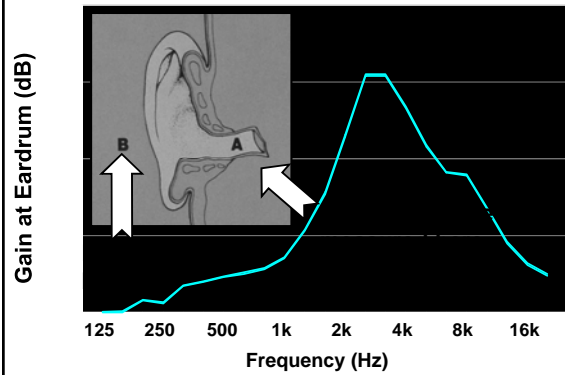


Ear and Hearing, 2004

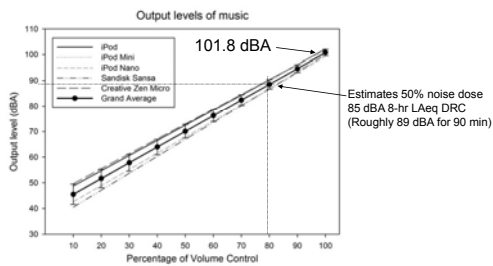


Fligor & Cox (2004)

Transfer Function of the Open Ear



The "80-90 Rule" for using MP3 players



Portnuff CDF, Fligor BJ, Arehart KH. Teenage use of portable listening devices: A hazard to hearing? JAAA. In press.

Fligor and Ives, In review

100 Subjects, 4 earphones, 4 listening environments

PCO School of Audiology

Koss
KSC11



Apple iPod
Stock



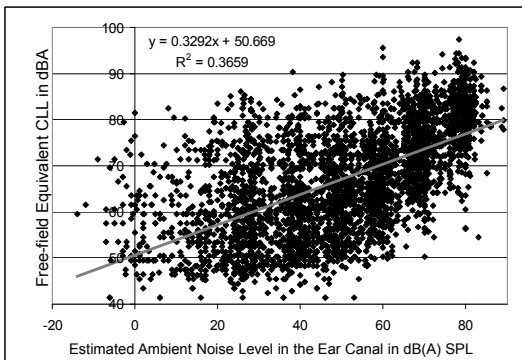
Sony
MDR-EX51LP



Etymotic
Research
ER6i



Individual Chosen Listening Level



What are real exposures using iPods?

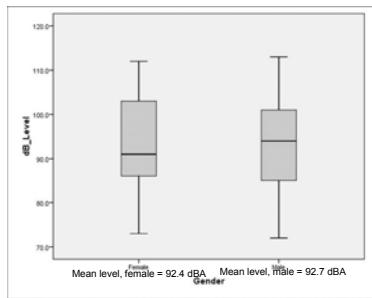
Listening Levels in NYC Levey, Levey & Fligor (2011)



Gershon, et al (2006)
subway = 83-106 dBA

Ambient, sidewalk
= 60.5 dBA

Listening Level, dBA

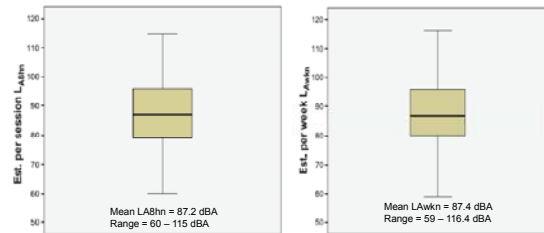


No significant
difference for
gender
($p > 0.05$)

Box-and-whisker plot showing listening level median,
interquartile range, and maximum and minimum

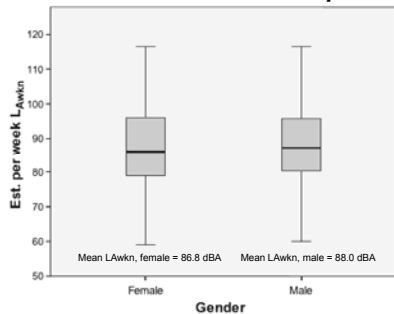
Williams (2005), Australia: CLL = 86.1 dBA (73.7-110.2)

Single-session and Weekly estimated sound exposures



Box-and-whisker plots showing equivalent continuous 8-hr and 40-hr levels
(Leq) for median, interquartile range, and maximum and minimum

Male vs. Female estimated sound exposures



No significant
difference for
gender
($p = 0.84$)

Box-and-whisker plot showing weekly average exposure
median, interquartile range, and maximum and minimum

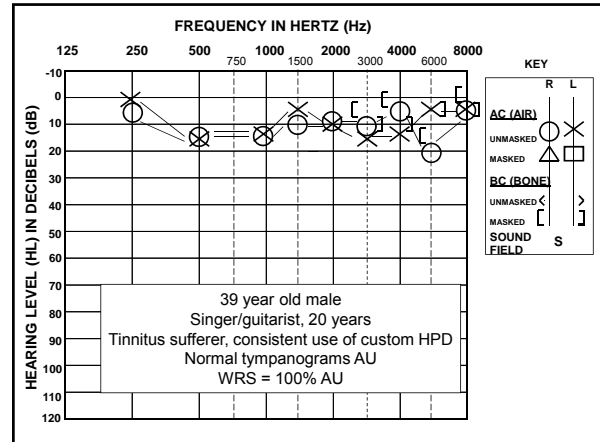
Elements of a Hearing Loss Prevention Program (HLPP)

Application to music exposure

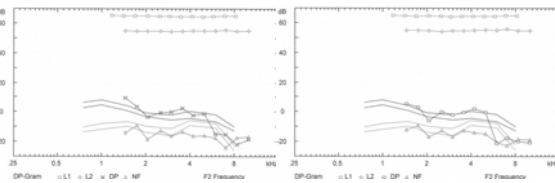
- Noise Survey (assessment)
- Engineering Controls
- Audiometric Monitoring
- Education and Motivation
- Hearing Protection Devices

Elements of a Hearing Loss Prevention Program (HLPP)

- Audiometric Monitoring
 - Comprehensive audiometry (air, bone, speech)
 - Immittance, +/- MEMR
 - DPOAEs, 1500-10k Hz, 4 freq's per octave
 - Tinnitus Reaction Questionnaire (Wilson, et al 1991): >17 = "clinically significant"
 - *At least annually*



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)

Elements of a Hearing Loss Prevention Program (HLPP)

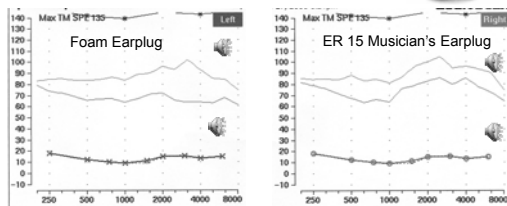
Application to music exposure

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

Flat Frequency Attenuators

Complaint against foam plug:

- “Muffling”/ “Distortion” - what is this?
- Change of timbre of music (change of harmonics relative to the fundamental frequency)
- Loss of natural ear canal resonance



Hypothetical Protected Sound Exposures: Bamboozle Road Show 2011

Leq (dBA)	105
Time (hrs)	4
Noise dose*	5000%
w/ ER9 (-9dB)	629%
w/ ER15 (-15dB)	158%
w/ ER25 (-25dB)	16%
w/ foam (-20dB)	50%

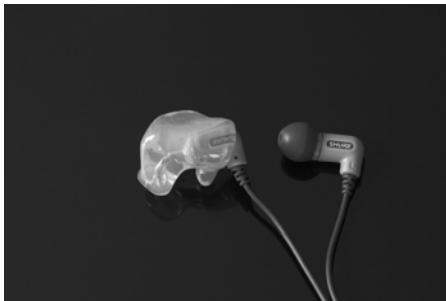
Table 3. Total audience exposure with hypothetical reduction in exposure from use of different HPD

Leq (dBA)	99
Time (hrs)	7
Noise dose*	2198%
w/ ER9 (-9dB)	277%
w/ ER15 (-15dB)	70%
w/ ER25 (-25dB)	7%
w/ foam (-20dB)	22%

Table 4. Total crew exposure with hypothetical reduction in exposure from use of different HPD

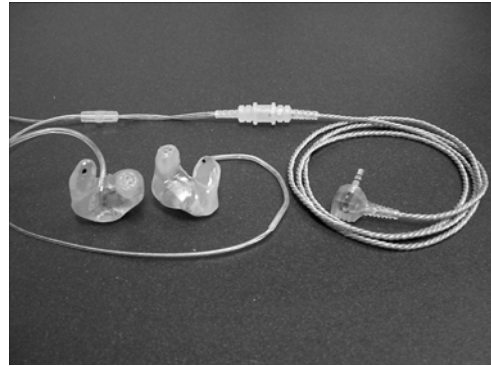
Audiology Today May/June 2011: pp 30-40

Reducing Levels on Stage: In Ear Monitors



Universal fit and custom sleeve

Used with permission by Sensaphonics



Used with permission from Sensaphonics

Modifying input from mix and ambient



**Dual Driver In-ear Monitor
With Ambient Microphones**

Elements of a Hearing Loss Prevention Program (HLPP)

Application to music exposure

- Noise Survey (assessment)
 - Engineering Controls
 - Audiometric Monitoring
 - Education and Motivation
 - Hearing Protection Devices
- The finances:
You are more obviously "selling" a service
– CPT Code: 92596 "Ear Protector Evaluation"

Management of NIHD

- Tinnitus
 - NIPTS
 - Hyperacusis
 - Diplacusis
1. Don't dabble, but don't limit your services (Use mentors!)
 2. Promote use of hearing aids, but know music as an input (it's NOT speech)
 3. Get to know audio engineers

Management of Tinnitus in musicians

Habituation of the Reaction
vs.
Habituation of the Perception

Conclusions

- ✓ This is not always “recreational” but it is “unregulated”
- ✓ Exposures are significant for risk for MIHD
- ✓ We have excellent tools for assessing MIHD, and early risk for MIHD
- ✓ Devices help us fulfill the promise of HLPP and management when MIHD hasn't been prevented... but they are not THE fix:
We are.