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- Email customerservice@AudiologyOnline.com
Prevention of Noise-Induced Hearing Loss from Recreational Firearms

Deanna K. Meinke Ph.D.

Disclaimer(s)

• Employed by the University of Northern Colorado

• Member of the Recreational Firearms Task Force for the National Hearing Conservation Association.

• Co-Director of the Dangerous Decibels Program
Learning Outcomes

After this course, participants will be able to:

- Identify at least three factors that increase the risk of noise-induced hearing loss from recreational shooting.
- Describe at least five hearing loss prevention strategies for individuals exposed to impulse noise from recreational firearms.
- Recognize the measurement considerations and limitations of conventional sound level meters used for gunshot measurements.
The Rudyard Gang

Rudyard Michigan, Data Collection Site
Who shoots firearms?
Demographics

- Civilians own 650 million firearms worldwide
- It is estimated that 46% of adult males and 13% of adult females in the United States have fired a gun at some point in their life
Starter Pistols
Occupational Firearm Exposure

~4.5 million workers

Police: 794,300

Military: ~Active & Reserve 1,211,575 (fluctuates)

Security & Gaming Surveillance Officers: 1,090,600

Game & Fish Wardens: 7,240


The Bang
Basics of a Gunshot (Impulse) Noise

1. Gunpowder burns, producing expanding gasses
2. Projectile is pushed forward by the force of the gasses
3. Projectile and gasses exit the muzzle of the gun.
   • Gasses cause a pressure (shock) wave that expands in three dimensions. Sound!

(see illustration in Rasmussen et al, 2009)

Prototypical Gunshot Waveform
Acoustic Characteristics
Recreational Firearms

- **Noise Type**: Impulsive
- **Level**: Peak SPL greater than 140 dB
- **Duration**: brief (<10 milliseconds outdoors)
- **Spectrum**: high frequency, with spectral peaks between 400 and 2,000 Hz

Enclosed Blinds
Gold Standard Measurement Approach

- 1/8” microphones (sens ≈ 1mV/Pa)
- 1/4” preamplifiers (Signal carrying capacity ≈ ±50V)
- Power modules (20 dB attenuation available)
- A/D and Data Acquisition board (4ch sampling: 800kS/s per channel, ±10V, 16-bit resolution)

Measuring Recreational Firearms

Rasmussen et al.
http://www.sandv.com/aug09.shtml
Rank-Ordered Range of Mean Unweighted Peak Sound Pressure Levels for Recreational Firearms

<table>
<thead>
<tr>
<th>Recreational Firearm Type</th>
<th>Peak Sound Pressure Level (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rifles (higher caliber than 0.22)</td>
<td>~159-174</td>
</tr>
<tr>
<td>Pistols (higher caliber than 0.22)</td>
<td>~149-171</td>
</tr>
<tr>
<td>Shotguns</td>
<td>~152-170</td>
</tr>
<tr>
<td>Starter pistols (blanks)</td>
<td>~148-165</td>
</tr>
<tr>
<td>Pistols (0.22 caliber)</td>
<td>~155-158</td>
</tr>
<tr>
<td>Rifles (0.17 and 0.22 caliber)</td>
<td>~140-144</td>
</tr>
<tr>
<td>Air Rifles</td>
<td>~117-134</td>
</tr>
</tbody>
</table>

1Measured at the LEFT EAR of a right-handed shooter with a gold standard measurement system
**Bystander Impulse Exposure:** ~149-167 dB peak SPL
Athletes and Officials

Each SLM meter tested at 5 different peak SPLs: 130, 140, 150, 160 and 170 dB
• Use of a commercial sound level meter utilized for impulse noise measurements may underestimate auditory hazard for impulse sound levels at or above approximately 150 dB peak SPL.

• Purchasing a new 1/8 inch microphone may not necessarily extend the range of your measurements.

Noise Thermometers

http://multimedia.3m.com/mws/media/1074386O/decibelscale-noise-meter.JPG

http://www/howardleight.co.uk/hearing-protection/noise-thermometer

Auditory Risk from Firearm Noise Exposure

Damage Risk Criteria for Impulse Noise

- **Impulse waveform** parameter-based
  - Peak amplitude
  - Pressure wave
  - Envelope duration

- **Total energy** within the impulse
  - Integrated A-weighted 8-hour equivalent level

- **Theoretical physiological ear-based electroacoustic models of the auditory system**
  - E.g. Auditory Hazard Assessment Algorithm for Humans
Impulse Noise Exposure Limits referencing peak SPL

- **World Health Organization**
  - 140 dB peak SPL for adults
  - 120 dB peak SPL for youth

- **U.S. OSHA**
  - 140 dB SPL for occupational exposures

- **European Union**
  - 137 dB C-weighted peak SPL limit

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### Table 2: Prevalence of Hearing Impairment Related to Firearm Use, U.S. Adults Age 20–69 years, NHANES, 2011–2012

<table>
<thead>
<tr>
<th>Firearms, Including Use for Recreation, Job, or Military (NHANES 2011–2012), U.S. Adults Age 20–69 Y</th>
<th>Prevalence (%)</th>
<th>Speech-Frequency Hearing Impairment, % (95% CI)</th>
<th>Overall</th>
<th>Unilateral</th>
<th>Bilateral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not used</td>
<td>54.3</td>
<td>11.4 (9.1–14.2)</td>
<td>6.0 (4.5–8.0)</td>
<td>5.4 (4.3–6.8)</td>
<td></td>
</tr>
<tr>
<td>Yes used</td>
<td>45.7</td>
<td>17.2 (13.6–21.6)</td>
<td>7.3 (6.7–9.6)</td>
<td>10.0 (7.3–13.6)</td>
<td></td>
</tr>
<tr>
<td>&lt;1,000 lifetime rounds fired</td>
<td>32.6</td>
<td>14.0 (10.6–18.2)</td>
<td>6.0 (4.2–8.4)</td>
<td>8.0 (5.8–10.9)</td>
<td></td>
</tr>
<tr>
<td>≥1,000 lifetime rounds fired</td>
<td>12.9</td>
<td>26.0 (19.7–33.4)</td>
<td>10.8 (8.4–13.7)</td>
<td>15.2 (9.4–23.6)</td>
<td></td>
</tr>
<tr>
<td>High-Frequency Hearing Impairment, % (95% CI)</td>
<td>Overall</td>
<td>Unilateral</td>
<td>Bilateral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not used</td>
<td>54.3</td>
<td>25.9 (23.5–28.6)</td>
<td>11.6 (10.1–13.2)</td>
<td>14.4 (12.7–16.3)</td>
<td></td>
</tr>
<tr>
<td>Yes used</td>
<td>45.7</td>
<td>37.1 (31.9–42.8)</td>
<td>12.3 (9.4–15.9)</td>
<td>24.8 (20.6–29.5)</td>
<td></td>
</tr>
<tr>
<td>&lt;1,000 lifetime rounds fired</td>
<td>32.6</td>
<td>32.2 (26.8–38.2)</td>
<td>10.2 (6.3–15.0)</td>
<td>22.1 (17.6–27.4)</td>
<td></td>
</tr>
<tr>
<td>≥1,000 lifetime rounds fired</td>
<td>12.9</td>
<td>49.7 (40.2–59.2)</td>
<td>18.0 (13.1–24.2)</td>
<td>31.7 (22.5–42.8)</td>
<td></td>
</tr>
</tbody>
</table>

CI, confidence interval; NHANES, National Health and Nutrition Examination Survey

Note: Adapted from Hoffman et al. 1, 3

1. Defined as pure tone average of thresholds at 0.5, 1, 2, and 4 kHz greater than 25 dB hearing loss.
2. Refers to the sums of unilateral and bilateral hearing impairment, which means hearing loss in one or both ears.
3. Refers to the pure tone average in only one ear exceeds 25 dB hearing loss.
4. Refers to the pure tone average in both ears exceeds 25 dB hearing loss.
5. Defined as pure tone average of thresholds at 3, 4, and 6 kHz greater than 25 dB hearing loss.
Occupational Noise Exposure Combined with Firearm Exposure

- Significantly poorer high-frequency hearing has been reported in
  - Blue collar workers
  - Farmers
  - Manufacturing workers
  - Railway workers
  - Forestry workers
  - Construction workers
  - Mining workers
- who use firearms, compared with respective cohorts who do not shoot.
The Demand for Audibility
Hearing Protection Devices Designed for Shooting Sports
Impulse Peak Insertion Loss
3M/E-A-R Combat Arms Earplug

(Slide courtesy of Bill Murphy, NIOSH)
Fit is Critical

Recoil at or above
170 dB peak SPL physical
force of the blast
STRATEGIES TO PREVENT HEARING LOSS WHEN SHOOTING RECREATIONAL FIREARMS

- Always wear well-fit earplugs and/or earmuffs when shooting or when positioned near others who are shooting*
- Avoid the use of muzzle brakes (ports)
- Reduce the number of shots fired
- Shoot smaller caliber/gauge firearms when possible
- Shoot firearms with longer barrel lengths when possible

*The use of hearing protection is still warranted even when implementing the other listed strategies.

STRATEGIES TO PREVENT HEARING LOSS WHEN SHOOTING RECREATIONAL FIREARMS

- Avoid shooting in groups, and if necessary, increase distance between shooters.
- Avoid firing simultaneously with other nearby shooters
- Shoot outdoors or in a sound-treated indoor environment
- Avoid shooting over hard reflective surfaces such as benches or tabletops
- Shoot sub-sonic or low-velocity (<1120 fps) ammunition when feasible
- Utilize a suppressor

*The use of hearing protection is still warranted even when implementing the other listed strategies.
Partnerships

AIM to be an informed resource in your community!
References

- References from the Seminars in Hearing article are provided in the supplemental PDF.

Thank you!  Deanna.Meinke@unco.edu