Auditory Risk Estimates for Youth Target Shooting

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Shooting Starts Young
NIHL in kids

Hearing loss in children attributed to sound exposure:

- **15.5%** of 12-19 year olds  Niskar et al. 2001
- **16.8%** of 12-19 year olds  Henderson et al. 2011
Sound Risks: Firearms
World Health Organization: Children

For children:

- < 70 dBA 24-hr $L_{eq}$
- NO exposures over 120 dB peak SPL

Berglund, Lindvall & Schwela: WHO 1999
Youth Target Shooting
Youth Target Shooting: Sitting on Ground
Youth Target Shooting: Over a Surface
Muzzle Position
Experimental Design:
2 Shooting Positions: 3 Types of Firearms
Instrumentation & Data Export

- 1/8” microphones (sensitivity $\approx 1$ mV/Pa)
- 1/4” preamplifiers (Signal carrying capacity $\approx \pm 50$ V)
- Power modules (20dB attenuation available)
- A/D and Data Acquisition board (4ch sampling: 800kS/s, $\pm 10$ V, 16-bit resolution)
- Text file output to MATLAB processing
Microphone Positions: Youth Standing Height
Microphone Positions: Youth Standing Height
Microphone Positions
Firearms

- Rifles (n=11)
  - Browning X-Bolt .30-06
  - Marlin .17 V5 HMR
  - Mossberg Int’l 702 Plinkster .22
  - Ruger 10/22, .22 LR (pink)
  - Remington 514 .22
  - Remington 742 Woodsmaster .30-06
  - Rossi Trifecta .22
  - Rossi Trifecta .243
  - Steyer-Daimler .270
  - Winchester 70XTR 7mm Mauser
  - Winchester Model 94 .30-30
Firearms

- **6 Shotguns**
  - Mossberg 183 KE .410
  - New England Firearms Partner SBI .410
  - Pietro .20 ga.
  - Remington 11_87 .12 ga .
    (with turkey choke)
  - Remington 870 Express Magnum .12 ga
  - Rossi Trifecta .20 ga

- **4 Pistols**
  - Colt Anaconda .44 magnum
  - Ruger GP100 .357 magnum
  - Ruger MK .22 long rifle
  - Smith & Wesson .22 long rifle
Ammunition

- .22
- .17 HMR
- .30-06
- 20 ga. Heavy load 2
- 12 ga. 2 ¾” light load
- 12 ga. 2 ¾” heavy load
- 12 ga, 3 ½” heavy load

5 shots each firearm/ammunition combination
Analysis

- Acoustic characteristics
  - Peak SPL (unweighted)
  - $L_{eqA8}$ dB SPL
- Maximum Permissible Exposures (MPE):
  1. $L_{eqA8}$ MPE
RIFLES: Mean Peak dB SPL
Shooter’s Ear

- Remington .30-06 carbine: 164 dB
- Browning .30-06: 160 dB
- Steyr-Daimler .270: 163 dB
- Rossi Trifecta .243: 166 dB
- Winchester .30-.30: 163 dB
- Winchester 7mm Mauser: 165 dB
- Marlin .17: 158 dB
- Rossi Trifecta .22: 144 dB
- Mossberg .22: 144 dB
- Ruger .22 LR: 144 dB
- Remington .22: 140 dB

Mean Peak dB SPL: 2.44 dB
RIFLES: Mean LeqA8
Shooter’s Ear

- Remington .30-06 carbine
- Steyr-Damiler .270
- Browning .30-06
- Rossi Trifecta .243
- Winchester .30-.30
- Winchester 7mm Mauser
- Marlin .17

- Rossi Trifecta .22
- Ruger .22 LR
- Mossberg .22
- Remington .22

85 dB LeqA8
RIFLES: LeqA8 MPE
Shooter’s Ear

1 shot or less
SHOTGUNS: Mean Peak dB SPL

Shooter’s Ear

- Rossi Trifecta 20 ga. #8 shot
- Remington 11-87 12 ga. with turkey choke
- Remington 11-87 12 ga.
- Remington 870 12 ga. #4 shot
- Rossi Trifecta 20 ga. #5 shot
- New England Firearms .410
- Remington 870 12 ga. #8 shot
- Pietro Barreta 20 ga.
- Mossberg .410 #7.5 shot
- Mossberg .410 #4 shot

Mean Peak dB SPL
SHOTGUNS: Mean LeqA8
Shooter’s Ear

- Rossi Trifecta 20 ga. #8 shot
- Remington 11-87 12 ga. with turkey choke
- Remington 11-87 12 ga.
- Remington 870 12 ga. #4 shot
- Rossi Trifecta 20 ga. #5 shot
- New England Firearms .410
- Remington 870 12 ga. #8 shot
- Pietro Barreta 20 ga.
- Mossberg .410 #7.5 shot
- Mossberg .410 #4 shot

Mean LeqA8 dB SPL

85 dB LeqA8
SHOTGUNS: LeqA8 MPE
Shooter’s Ear

- Rossi Trifecta 20 ga. #8 shot
- Remington 11-87 12 ga. with turkey choke
- Remington 11-87 12 ga.
- Remington 870 12 ga. #4 shot
- Rossi Trifecta 20 ga. #5 shot
- New England Firearms .410
- Remington 870 12 ga. #8 shot
- Pietro Barreta 20 ga.
- Mossberg .410 #7.5 shot
- Mossberg .410 #4 shot

LeqA8 MPE
PISTOLS: Mean Peak dB SPL
Shooter’s Ear

- Ruger .357 Magnum Revolver Rem. .357 Ammo
- Colt .44 Magnum Revolver XTP Ammo
- Ruger .357 Magnum Revolver Win .38 Ammo
- Colt .44 Magnum Revolver Silvertip Ammo
- Smith & Wesson .22 LR Revolver
- Ruger MK .22 Long Rifle

Mean Peak dB SPL

~4 dB
Pistols: Mean Peak dB SPL

Shooter's Ear

Standing

165.7 dB SPL

File: TEST46, Mic Ch. 2, Peak Level: 165.7 dB SPL

Tabletop

170.3 dB SPL

File: TEST62, Mic Ch. 2, Peak Level: 170.3 dB SPL

Colt .44 Magnum Revolver XTP Ammo
PISTOLS: Mean LeqA8
Shooter’s Ear

- Ruger .357 Magnum Revolver Rem. .357 Ammo
- Colt .44 Magnum Revolver XTP Ammo
- Ruger .357 Magnum Revolver Win .38 Ammo
- Colt .44 Magnum Revolver Silvertip Ammo
- Smith & Wesson .22 LR Revolver
- Ruger MK .22 Long Rifle

Mean LeqA8 dB SPL

85 dB LeqA8
SHOTGUNS: LeqA8 MPE
Shooter’s Ear

- Ruger .357 Magnum Revolver Rem. .357 Ammo
- Colt .44 Magnum Revolver XTP Ammo
- Ruger .357 Magnum Revolver Win .38 Ammo
- Colt .44 Magnum Revolver Silvertip Ammo
- Smith & Wesson .22 LR Revolver
- Ruger MK .22 Long Rifle

Legend:
- MPELeqA8Numb_Stand
- MPELeqA8Numb_Table
<table>
<thead>
<tr>
<th>Firearm Type</th>
<th>Condition</th>
<th>Mean Peak (dB SPL)</th>
<th>Mean LeqA8 (dB SPL)</th>
<th>Mean MPE (LeqA8)</th>
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<tbody>
<tr>
<td><strong>Rifles</strong></td>
<td>Standing</td>
<td>~139-164</td>
<td>~64-86</td>
<td>0-133</td>
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<td>Tabletop</td>
<td>~140-166</td>
<td>~65-88</td>
<td>0-105</td>
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<td><strong>Differences</strong></td>
<td>0.3 to 2.4</td>
<td>0.3 to 2.4</td>
<td>0 to 132</td>
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<td><strong>Shotguns</strong></td>
<td>Standing</td>
<td>~154-162</td>
<td>76-83</td>
<td>1-8</td>
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<td></td>
<td>Tabletop</td>
<td>----</td>
<td>----</td>
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</tr>
<tr>
<td><strong>Pistols</strong></td>
<td>Standing</td>
<td>~157-169</td>
<td>~78-88</td>
<td>0 to 4</td>
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<td>Tabletop</td>
<td>~156-171</td>
<td>~78-91</td>
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<tr>
<td></td>
<td><strong>Differences</strong></td>
<td>1.17 to 3.97</td>
<td>0 to 3.4</td>
<td>0 to 4</td>
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</table>
Conclusions: Auditory Hazard

- All youth firearms exceeded 120 dB SPL peak levels recommended for children, and all weapons exceed 140 dB SPL adult recommendation, in fact all exceeded 150 dB SPL except for .17 and .22 caliber rifles.

- The mean peak SPLs of high-powered pistols exceed high-powered rifles and increase hearing risk.

- Rifles vary by as much as 20 dB in mean peak levels, resulting in 100 times higher exposure when compared to lowest .22 caliber. Shotguns and pistols show less variability within class (~8-11 dB).
Conclusions: Choice of Firearm

- When selecting a youth rifle or pistol, a .22 caliber is safer than higher powered firearms.
- When selecting a youth shotgun, consider selecting a smaller cartridge.
- Longer barrels may also be advantages in terms of auditory risk, but may be more difficult for youth to maneuver.
Conclusion: Shooting Position

- Standing is a safer shooting position in terms of auditory risk, especially for pistols.
Hearing Protection Implications

- Youth should always wear hearing protection when shooting.

- Consider the need for speech audibility when instructing or hunting with youth who are wearing hearing protectors.

- Adults need to model HPD use.
Education is Critical
THANK YOU!
Sound Risks: Firearms

Bystanders at greater risk than shooter: 149-167 peak dB SPL
• Henderson et al. 2011: 12-19 year olds

Prevalence of audiograms suggestive of NIHL

<table>
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<tr>
<th>Year</th>
<th>Males</th>
<th>Females</th>
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<tbody>
<tr>
<td>1988-1994</td>
<td>20.2%</td>
<td>11.6%</td>
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<tr>
<td>2005-2006</td>
<td>17.0%</td>
<td>16.7%</td>
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