Helmets and Neck Injuries in Fatal Motorcycle Crashes

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Examination of vehicles and crash scene
Reconstruction

#9
Motorcycle Crash speed

Cumulative Percent

Motorcycle Crash Speed, mph

No Helmet (n=241)
Helmet (n=59)
Distribution of Most Severe Somatic (Below-the-Neck) Injury in Fatal Motorcycle Crashes

Severity of Most Severe Somatic Injury

<table>
<thead>
<tr>
<th></th>
<th>Helmet (n=60)</th>
<th>No Helmet (n=244)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Minor</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>Moderate</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Serious</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>Severe</td>
<td>28</td>
<td>27</td>
</tr>
<tr>
<td>Critical</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Maximum</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>
Fatality Rate as a Function of Most Severe Somatic Injury, Combined USC & Thailand Data

Severity of Most Severe Somatic Injury

- None
- Minor
- Moderate
- Serious
- Severe
- Critical
- Maximum

Helmet (n=774)
- None: 0%
- Minor: 2%
- Moderate: 1%
- Serious: 3%
- Severe: 33%
- Critical: 90%
- Maximum: 89%

No Helmet (n=1065)
- None: 0%
- Minor: 1%
- Moderate: 1%
- Serious: 0%
- Severe: 33%
- Critical: 90%
- Maximum: 89%

Percent
Fatality Rate as a Function of Most Severe Somatic Injury, Combined USC & Thailand Data

Severity of Most Severe Somatic Injury

Helmet (n=774) vs No Helmet (n=1065)

Percent

None Minor Moderate Serious Severe Critical Maximum

0 2 1 1 0 3 3 15 33 90 89 100

Helmet (n=774)
No Helmet (n=1065)
Neck Injury Type and Frequency, All 304 Riders

- Spinal Cord
- C1-C2 Fracture
- C3-C7 Fracture
- C1-C2 Subluxation, Dislocation
- C3-C7 Subluxation, Dislocation
- Blood Vessel
- Vertebral Arteries
- Carotid Sheath
- Nerve plexus
- Neck Muscle
- Throat

Helmet Worn (n=60)
No Helmet (n=244)
Neck Injury Type and Frequency among Riders with Most Severe Somatic AIS>3

- No Helmet (n=124)
- Helmet (n=38)

- Spinal Cord
- Spinal Fracture
- C1-C2 Fracture
- C3-C7 Fracture
- Spinal Subluxation, Dislocation
- C1-C2 Subluxation, Dislocation
- C3-C7 Subluxation, Dislocation
- Vertebral Artery
- Carotid Sheath
- Other Hemorrhage
- Neck Muscle
- Throat
Spinal Cord & Column Injuries, All 304 Riders

- Spinal Cord: 31.6% (Helmet Worn) vs. 34.7% (No Helmet)
  - $\chi^2 = 0.672$, $p = 0.413$

- C1-C2 Fracture: 10.5% (Helmet Worn) vs. 6.5% (No Helmet)
  - $\chi^2 = 0.069$, $p = 0.793$

- C3-C7 Fracture: 18.4% (Helmet Worn) vs. 15.4% (No Helmet)
  - $\chi^2 = 0.672$, $p = 0.413$

- C1-C2 Subluxation or Dislocation: 15.4% (Helmet Worn) vs. 59.7% (No Helmet)
  - $\chi^2 = 2.158$, $p = 0.142$

- C3-C7 Subluxation or Dislocation: 21.1% (Helmet Worn) vs. 13.8% (No Helmet)
  - $\chi^2 = 7.182$, $p = 0.007$
Spinal Cord & Column Injuries, Riders with AIS>3

- Spinal Cord
  - Helmet Worn (n=60): 36.7%
  - No Helmet (n=244): 31.1%
  - $\chi^2 = 1.157, p = 0.282$

- C1-C2 Fracture
  - Helmet Worn (n=60): 8.3%
  - No Helmet (n=244): 9.4%
  - $\chi^2 = 0.704, p = 0.401$

- C3-C7 Fracture
  - Helmet Worn (n=60): 23.6%
  - No Helmet (n=244): 30.0%
  - $\chi^2 = 0.190, p = 0.663$

- C1-C2 Subluxation or Dislocation
  - Helmet Worn (n=60): 71.7%
  - No Helmet (n=244): 61.5%
  - $\chi^2 = 0.457, p = 0.499$

- C3-C7 Subluxation or Dislocation
  - Helmet Worn (n=60): 26.7%
  - No Helmet (n=244): 12.3%
  - $\chi^2 = 0.125, p = 0.724$
Neck Soft Tissue Injuries, All 304 Riders

<table>
<thead>
<tr>
<th>Condition</th>
<th>Helmet (n=60)</th>
<th>No Helmet (n=244)</th>
<th>χ²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Blood Vessel</td>
<td>83.3</td>
<td>76.2</td>
<td>1.400</td>
<td>.237</td>
</tr>
<tr>
<td>Vertebral Arteries</td>
<td>50</td>
<td>45.5</td>
<td>.394</td>
<td>.530</td>
</tr>
<tr>
<td>Carotid Sheath</td>
<td>65</td>
<td>48.4</td>
<td>5.399</td>
<td>.021</td>
</tr>
<tr>
<td>Nerve plexus</td>
<td>60</td>
<td>44.7</td>
<td>4.535</td>
<td>.033</td>
</tr>
<tr>
<td>Neck Muscle</td>
<td>66.7</td>
<td>57</td>
<td>1.871</td>
<td>.171</td>
</tr>
<tr>
<td>Throat</td>
<td>20</td>
<td>15.6</td>
<td>.687</td>
<td>.407</td>
</tr>
</tbody>
</table>

Percent

χ² = 1.400, p = .237
χ² = .394, p = .530
χ² = 5.399, p = .021
χ² = 4.535, p = .033
χ² = 1.871, p = .171
χ² = .687, p = .407
Neck Soft Tissue Injuries, Riders with Somatic AIS<4

- Any Blood Vessel: $\chi^2 = 0.000, p = .982$
  - Helmet (n=38): 72.7%
  - No Helmet (n=124): 72.5%

- Vertebral Arteries: $\chi^2 = .130, p = .719$
  - Helmet: 45.8%
  - No Helmet: 50%

- Carotid Sheath: $\chi^2 = .143, p = .705$
  - Helmet: 43.3%
  - No Helmet: 50%

- Nerve plexus: $\chi^2 = .126, p = .723$
  - Helmet: 40.9%
  - No Helmet: 36.7%

- Neck Muscle: $\chi^2 = .135, p = .720$
  - Helmet: 59.1%
  - No Helmet: 55%

- Throat: Fisher Exact test, $p = .698$
  - Helmet: 12.5%
  - No Helmet: 27.3%

Percent

Helmet (n=38), No Helmet (n=124)
Effect of Helmet Weight
Helmet Weight and Spinal Cord Injury

<table>
<thead>
<tr>
<th>Helmet weight, pounds</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.75-1.99</td>
<td>1</td>
</tr>
<tr>
<td>2.00-2.24</td>
<td>2</td>
</tr>
<tr>
<td>2.25-2.49</td>
<td>6</td>
</tr>
<tr>
<td>2.50-2.74</td>
<td>6</td>
</tr>
<tr>
<td>2.75-2.99</td>
<td>4</td>
</tr>
<tr>
<td>3.00-3.24</td>
<td>1</td>
</tr>
<tr>
<td>3.25+</td>
<td>1</td>
</tr>
<tr>
<td>Unknown</td>
<td>7</td>
</tr>
</tbody>
</table>

- Spinal cord injury +
- No spinal cord injury
Helmet Weight and Cervical Spine Fracture

- **Frequency**
  - C-Spine fractured
  - No C-spine Fx

- **Helmet weight, pounds**
  - 1.75-1.99
  - 2.00-2.24
  - 2.25-2.49
  - 2.50-2.74
  - 2.75-2.99
  - 3.00-3.24
  - 3.25+
  - Unknown

- **Data**
  - [Frequency values for each weight category]
Helmet Weight and C1-C2 Subluxation or Dislocation

The bar chart illustrates the frequency of helmet weights and whether there was C1-C2 subluxation or dislocation. The chart includes categories for helmet weights ranging from 1.75 to 1.99 pounds, 2.00 to 2.24 pounds, 2.25 to 2.49 pounds, 2.50 to 2.74 pounds, 2.75 to 2.99 pounds, 3.00 to 3.24 pounds, 3.25 pounds and above, and a category for unknown weights. The data shows the number of occurrences in each category, with a distinction between those with and without C1-C2 subluxation or dislocation.
Helmet Weight and C3-C7 Subluxation or Dislocation

<table>
<thead>
<tr>
<th>Helmet weight, pounds</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.75-1.99</td>
<td>2</td>
</tr>
<tr>
<td>2.00-2.24</td>
<td>3</td>
</tr>
<tr>
<td>2.25-2.49</td>
<td>8</td>
</tr>
<tr>
<td>2.50-2.74</td>
<td>9</td>
</tr>
<tr>
<td>2.75-2.99</td>
<td>2</td>
</tr>
<tr>
<td>3.00-3.24</td>
<td>4</td>
</tr>
<tr>
<td>3.25+</td>
<td>5</td>
</tr>
<tr>
<td>Unknown</td>
<td>7</td>
</tr>
</tbody>
</table>

- C3-C7 Sublux/Disloc
- No C3-C7 Sublux/Disloc
Vertebral Artery Anatomy
Helmet Weight and Vertebral Artery Injury

Frequency

Helmet weight, pounds

Vertebral artery injury
No injury

1
2
4
5
7
2
2
3
4
6

1 2 4 5 6 7 2 2 3 4 6
Carotid Sheath Contents: Common Carotid Artery, Internal Jugular Vein & Vagus Nerve
Carotid Sheath Contents: Common Carotid Artery, Internal Jugular Vein & Vagus Nerve
Helmet Weight and Carotid Sheath Hemorrhage

Frequency

Helmet weight, pounds

- Carotid injury
- No Carotid Sheath Injury
Helmet Weight and Hemorrhage Surrounding Nerve Trunks or Nerve Plexes

<table>
<thead>
<tr>
<th>Helmet weight, pounds</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1/4-2</td>
<td>1</td>
</tr>
<tr>
<td>2 1/4-2 1/2</td>
<td>6</td>
</tr>
<tr>
<td>2 1/2-2 1/4</td>
<td>6</td>
</tr>
<tr>
<td>2 1/4-3</td>
<td>4</td>
</tr>
<tr>
<td>3 1/4-3 1/2</td>
<td>5</td>
</tr>
<tr>
<td>3 1/4+</td>
<td>4</td>
</tr>
<tr>
<td>Unknown</td>
<td>6</td>
</tr>
</tbody>
</table>

- **Nerve / plexus injury**
- **None**
Conclusions 1

1. About 5% of crashes are fatal. They are NOT representative of the motorcycle crash population.
2. Unhelmeted riders are 2-3 times as likely to die in a crash as helmeted riders.
3. Unhelmeted riders are more likely to die in a crash despite having only relatively minor below-the-neck injuries.
4. Helmets are especially effective in preventing death in serious-to-severe crashes.
5. Helmet users showed statistically insignificant increases in many injuries reported here.
Conclusions 2

6. The risk of spinal cord injuries or cervical spine fractures in these fatal crashes was no higher among helmet users than non-users.

7. Three kinds of injuries were more common among helmeted riders:
   a. Cervical spine subluxation and dislocation
   b. Hemorrhage in the carotid sheath
   c. Hemorrhage around nerve trunks and plexes

8. Helmet weight had no consistent effect on any injury except perhaps hemorrhage in the carotid sheath and around nerve trunks and plexes.
Thank You