The Value of Non-Fatal Injuries of Various Severities for Use in Terrorism-Related Policy Analyses


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Introduction

• Terrorist attacks can result in many different consequences, e.g.:
  – deaths
  – injuries
  – property damage
  – business interruption

• Terrorism risk analysis involved assessing:
  – costs of deaths and injuries in terrorist attacks
  – weighing (trading off) mortality and/or morbidity reductions against educating the other potential consequences of terrorism
VSL in Terrorist Attacks

• Value of a statistical life (VSL): willingness to pay to prevent one statistical life lost

  – benefit transfer of VSLs from other risk areas to terrorism risk space
  – 2013$ (CPI): $7.0 M (95% c.i. $5.5-$8.9 M)
  – to be doubled in sensitivity analyses
VSI in Terrorist Attacks

• Value of a statistical injury (VSI): willingness to pay to prevent injury of some severity

• Robinson et al.’s study does not address terrorism value of statistical injury (VSI)

• Many terrorism risk and consequence analyses sidestep issue by examining only fatal injuries

  – $100,000 to $500,000 (2011$) for “serious” injuries (prohibiting normal life function at least one year)
Goals and Scope

• Research question:
  – What are appropriate and consistent ways of estimating the economic value of avoiding injuries of various severities in terrorist attacks?

• Physical injuries only
  – not psychological/emotional trauma (e.g., PTSD)
  – not disease-related morbidity (e.g., biological agents)

• Various types of injury costs:
  – cost of injury (medical expenses, lost work)
  – quality-related (pain and suffering, disability and impairment)
  – revealed preference/willingness to pay
Assessing Injury Severity

• Abbreviated Injury Scale (AIS)
  – AIS 1 (minor) to AIS 6 (maximal, often fatal)
  – first published in 1971 by Association for the Advancement of Automotive Medicine
  – developed through expert deliberation and consensus
  – maximum AIS (MAIS) for multiple injuries

• Injury Severity Score (ISS)
  – developed by Baker et al. (1974) for 2,128 motor vehicle accident injuries
  – sum of scales of highest AIS values in three different body regions
  – range: 1-75, but only 44 possible values
  – explained 49% of variance in mortality (25% for MAIS)
# Abbreviated Injury Scale

<table>
<thead>
<tr>
<th>Severity</th>
<th>Example Injuries</th>
<th>General Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS 1</td>
<td>Minor Abrasion; laceration; contusion</td>
<td>Can be treated and released</td>
</tr>
<tr>
<td>AIS 2</td>
<td>Moderate Simple broken bone; serious strain/sprain</td>
<td>Requires follow-up and weeks to months to heal</td>
</tr>
<tr>
<td>AIS 3</td>
<td>Serious Complicated fracture; concussion; minor crush injury</td>
<td>Requires substantial follow-up; some minor disability likely</td>
</tr>
<tr>
<td>AIS 4</td>
<td>Severe Heart laceration; loss of limb</td>
<td>Hospitalization; substantial temporary and moderate long-term disability</td>
</tr>
<tr>
<td>AIS 5</td>
<td>Critical Crush syndrome with kidney failure; massive head injury</td>
<td>Extended hospitalization; significant long-term disability</td>
</tr>
<tr>
<td>AIS 6</td>
<td>Maximum Decapitation; cervical spine contusion at C3; partial thickness burns to &gt;90% of body</td>
<td>Usually (though not invariably) fatal</td>
</tr>
</tbody>
</table>

AIS/ISS Pros and Cons

• Advantages
  – good compromise between clinical detail, usability
  – Widespread use
  – AIS levels have been linked to various injury values

• Disadvantages
  – subjectivity (expert consensus) and reliability (ratings done by many different people using various information sources)
  – correlate better with mortality/survival than other outcome measures (e.g., length of hospital stay)
  – more applicable to blunt trauma than penetrating injuries
AIS-Based Injury Values

• Cost of injury
  – Finkelstein et al. (2006): for U.S. injuries generally
  – Blincoe et al. (2002): for injuries in U.S. motor vehicle accidents

• Quality-related
  – DOT (2011): quality-adjusted portion of remaining life lost
  – Graham et al. (1997): Functional Capacity Index, convenience sample of 114 raters

• Revealed preference/willingness to pay
  – Willis & LaTourette (2008): apply high end of range to MAIS 2-5, and VSL to MAIS 6
AIS Injury Values, 2013$

<table>
<thead>
<tr>
<th>MAIS</th>
<th>Cost of Injury</th>
<th>Quality-Related</th>
<th>RP/WTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAIS 1</td>
<td>$4,500</td>
<td>$8,000</td>
<td>$21,000</td>
</tr>
<tr>
<td>MAIS 2</td>
<td>$13,000</td>
<td>$84,000</td>
<td>$330,000</td>
</tr>
<tr>
<td>MAIS 3</td>
<td>$41,000</td>
<td>$240,000</td>
<td>$740,000</td>
</tr>
<tr>
<td>MAIS 4</td>
<td>$110,000</td>
<td>$460,000</td>
<td>$1.9 M</td>
</tr>
<tr>
<td>MAIS 5</td>
<td>$110,000</td>
<td>$1.5 M</td>
<td>$4.2 M</td>
</tr>
<tr>
<td>MAIS 6*</td>
<td>$1.3 M</td>
<td>$1.3 M</td>
<td>$7.0 M</td>
</tr>
</tbody>
</table>

*fatal

RP = revealed preference; WTP = willingness to pay; MAIS = maximum Abbreviated Injury Scale
AIS/ISS in Terrorism Events

- Literature review of works that examine injury severity in terrorist attacks
  - English language publications (published any time)
  - peer-reviewed journals (one exception made)
  - examines injuries in terrorist attacks or mass shootings
  - MAIS distribution or ISS histogram with 3+ levels (quantitative)
# AIS/ISS Terrorism Studies

<table>
<thead>
<tr>
<th>Study (chronologically)</th>
<th>Injury Metric(s)</th>
<th>Injury Victims</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brismar &amp; Bergenwald (1982)</td>
<td>MAIS; ISS</td>
<td>107</td>
<td>1980 rail station bombing, Bologna, Italy</td>
</tr>
<tr>
<td>Adler et al. (1983)</td>
<td>ISS</td>
<td>272</td>
<td>Various Israel bombings, 1975-1979</td>
</tr>
<tr>
<td>Frykberg et al. (1989)</td>
<td>MAIS; ISS</td>
<td>77</td>
<td>1983 U.S. Marine Barracks bombing, Beirut, Lebanon</td>
</tr>
<tr>
<td>Curran et al. (1990)</td>
<td>ISS</td>
<td>21</td>
<td>1987 Enniskillen bombing, N. Ireland</td>
</tr>
<tr>
<td>Carley &amp; Mackway-Jones (1997)</td>
<td>MAIS</td>
<td>168</td>
<td>1996 Manchester bombing, UK</td>
</tr>
<tr>
<td>Norville et al. (1999)/Mallonee et al. (1996)</td>
<td>ISS</td>
<td>673</td>
<td>1995 Murrah building bombing, USA</td>
</tr>
<tr>
<td>Cushman et al. (2003)</td>
<td>ISS</td>
<td>56</td>
<td>2001 9/11 attack, USA</td>
</tr>
<tr>
<td>Peral Gutierrez de Ceballos et al. (2005)</td>
<td>ISS</td>
<td>24</td>
<td>2004 Madrid train bombings</td>
</tr>
<tr>
<td>Kaplowitz et al. (2007)</td>
<td>ISS</td>
<td>23</td>
<td>2007 Virginia Tech University shooting, USA</td>
</tr>
<tr>
<td>Kim et al. (2010)</td>
<td>ISS</td>
<td>50</td>
<td>1927 Bath School Bombing, USA</td>
</tr>
<tr>
<td>Israel Ministry of Health (2011)</td>
<td>ISS</td>
<td>3,786</td>
<td>Summary from Israel Trauma Registry, 2000-2009</td>
</tr>
</tbody>
</table>

11 Studies / 5,350 Total Injury Victims
ISS Injury Values

• No ISS-specific injury values in literature
• ISS based on AIS, suggesting AIS injury values could be “mapped” onto the ISS scale
• At each MAIS level, ISS bounded between:
  – minimum: \((\text{MAIS})^2\), for AIS triplet \((\text{MAIS},0,0)\)
  – maximum: \(3(\text{MAIS})^2\), for AIS triplet \((\text{MAIS},\text{MAIS},\text{MAIS})\)
• Distribution of ISS values \(\rightarrow\) distribution of MAIS values
• Assume victims within each histogram level evenly distributed among all (valid) ISS values
### MAIS Terrorism Distributions

<table>
<thead>
<tr>
<th>MAIS</th>
<th>All Injuries</th>
<th>Severe Injuries Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>44%</td>
<td>22%</td>
</tr>
<tr>
<td>2</td>
<td>43%</td>
<td>38%</td>
</tr>
<tr>
<td>3</td>
<td>9%</td>
<td>20%</td>
</tr>
<tr>
<td>4</td>
<td>2%</td>
<td>10%</td>
</tr>
<tr>
<td>5</td>
<td>2%</td>
<td>8.5%</td>
</tr>
<tr>
<td>6</td>
<td>0.1%</td>
<td>0.6%</td>
</tr>
</tbody>
</table>
Variability in Injury Costs

- Injury values highly variable
- DOT (2011) recommends the use of a non-negative distribution (e.g., lognormal) with coefficient of variation (mean/sigma) of 45%
- Apply these log-normal distributions to the terrorism injury values
- 100,000 Monte Carlo simulations
# Terrorism VSI

<table>
<thead>
<tr>
<th>Victims</th>
<th>Injury Valuation Method(s)</th>
<th>VSI (2013$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5&lt;sup&gt;th&lt;/sup&gt; Percentile</td>
</tr>
<tr>
<td>All injuries</td>
<td>COI</td>
<td>$36,000</td>
</tr>
<tr>
<td>All injuries</td>
<td>RP/WTP</td>
<td>$35,000</td>
</tr>
<tr>
<td>Severely injured only</td>
<td>RP/WTP</td>
<td>$55,000</td>
</tr>
<tr>
<td>Severely injured only</td>
<td>COI</td>
<td>$82,000</td>
</tr>
<tr>
<td>All injuries</td>
<td>All combined (equal weight)</td>
<td>$150,000</td>
</tr>
<tr>
<td>All injuries</td>
<td>QOL</td>
<td>$300,000</td>
</tr>
<tr>
<td>Israel Trauma Registry</td>
<td>All combined (equal weight)</td>
<td>$300,000</td>
</tr>
<tr>
<td>Severely injured only</td>
<td>All combined (equal weight)</td>
<td>$310,000</td>
</tr>
<tr>
<td>Severely injured only</td>
<td>QOL</td>
<td>$590,000</td>
</tr>
</tbody>
</table>
Acknowledgements

• National Center for Risk and Economic Analysis of Terrorism Events (CREATE) based at the University of Southern California
  • Lisa Robinson
  • Adam Rose
References


References, Cont.


