Fatal traumatic brain injury in older adults in Austria 1980–2012: an analysis of 33 years

ALEXANDRA BRAZINOVÁ1,2, WALTER MAURITZ2,3, MAREK MAJDAN1,2, VERONIKA REHORČIKOVÁ1,2, JOHANNES LEITGEB4

1Department of Public Health, Faculty of Health Sciences and Social Work, Trnava University, Trnava 91843, Slovakia
2International Neurotrauma Research Organization, Wien A-1080, Austria
3Anaesthesiology and Intensive Care Medicine, Trauma Hospital ‘Lorenz Boehler’, Wien, Austria
4Department of Traumatology, University of Vienna, Wien, Austria

Address correspondence to: A. Brazinova. Tel: (+421) 918641974. Email: abrazinova@geh.org

Abstract

Background: traumatic brain injury (TBI) is a significant public health problem. Developed countries report a significant increase of TBI in older adults in the past decades. The objective of this study was to investigate the changes in TBI-related mortality in older Austrians (65 years or older) between 1980 and 2012 (33 years) and to identify possible causes for these changes.

Methods: data from Statistics Austria on mortality in Austria between 1980 and 2012 were screened and data on TBI-related mortality in adults aged 65 and older were extracted and analysed, based on the diagnostic codes of the International Classification of Diseases, 10th and 9th revision. Mortality rates were calculated for 5-year age groups; standardized mortality rates were calculated for the total. Mechanism of injury was analysed for all events, both sexes and individual age groups.

Results: between 1980 and 2012, 16,204 people aged 65 or older died from TBI in Austria; 61% of these were male. Fatal TBI cases and mortality rates increased in the oldest age groups (80 years or older). Half of the fatal TBI cases were caused by falls, 22% by traffic accidents and 17% by suicides. Rate of fall-related fatal TBI increased and rate of traffic accident-related fatal TBI decreased with age.

Conclusion: preventive measures introduced in the past decades in the developed countries have contributed to a decrease in traffic injuries. However, falls in the older population are on the rise, mainly due to ageing of the population, throughout the reported period. It is important to take preventive measures to stop the epidemics of fall-related TBIs and fatalities in older adults.

Keywords: traumatic brain injury deaths, epidemiology, mortality rate, age, sex, older people

Background

Traumatic brain injury (TBI) is a significant public health problem, causing fatalities and long-term impairment in its victims. In cases aged 1–40, it is one of the leading causes of death and long-term disability [1]. In developed countries, the highest mortality rate post-TBI is seen among individuals over 60 years of age [2]. Significant increases in the rates of geriatric TBI have been documented in last decades in studies from the United States [3], Italy [2] and Australia [4]. The majority of TBIs in older adults are caused by falls, and the ageing process may contribute to fall risks [5–8]. The recent increase of TBI incidence in older adults is explained by a rapidly ageing population that remains active for longer [8, 9]. However, some authors report that numbers of treated TBIs among older adults are increasing at a rate that exceeds population growth [6, 10].

We decided to look at the evidence of trends in TBI in older population in Austria. The objective of this study was to describe the changes in TBI-related mortality in older Austrians between 1980 and 2012 (33 years), and to identify possible causes for these changes.

Methods

Statistics Austria (the national statistics office) provided data on >3 million deaths that were recorded between 1 January 1980 and 31 December 2012. These are data from death certificates completed by examining physicians that are forwarded
to Statistics Austria by the register offices of all Austrian districts. Data on the total population size as well as on the age and sex subgroups for the years 1980–2012 were obtained from the website of Statistics Austria (www.statistik.at) using the proprietary ‘SuperWEB’ application provided there.

The diagnostic codes of the International Classification of Disease (ICD) stipulated by the US Centers for Disease Control [11] were used to identify deaths due to TBI. For deaths from 1980 to 2001, cases with the ICD-9 codes were used; for deaths from 2002 to 2012, it was ICD-10 codes. Cases where TBI was primary cause of death were extracted. The selected data included year and month of death, age, sex, residency of the cases and mechanism of accident (ICD-9 codes 8000–9890 and ICD-10 codes V01.1–Y89.9).

**Data analysis**

Data on TBI deaths of adults aged 65 or older were grouped into 5-year age groups. The average annual number of cases and mortality rates (MR; deaths/10^5 population/year) were calculated for each age group, for the total population and for both sexes. Standardised mortality rates were calculated using the direct method for the WHO World Standard Population. Mechanisms of injury were analysed for the whole population, both sexes, and for age groups. Kendall’s Tau coefficient of rank correlation was calculated and used for the interpretation of overall trends.

**Results**

Between 1980 and 2012, 47,827 Austrians died from TBI, out of which 16,204 (34%) were aged ≥65 (for comparison, 11% was in the age group 0–19 years). Most of the 65 years or older deaths were male (n = 9,903; 61%). The male:female ratio was constant over the whole study period. Figure 1 shows the crude TBI-related mortality rates in older Austrians, by age groups. Between the years 1980 and 2012, the trend of TBI-related mortality for the total 65 years or

![Figure 1. Crude TBI mortality rates in 1980–2012 in Austrians aged 65 or older, per 100,000, by individual age groups.](image-url)
older population decreased (65 years or older, \( \tau = -0.238 \)). For comparison, the trend of the total Austrian population of same age for the period 1980–2012 is steeply increasing (male, \( \tau = 0.866 \); female, \( \tau = 0.885 \); total, \( \tau = 0.908 \)). Trends of TBI-related mortality in individual age groups differed: the trend was decreasing for the first three age groups (65–69 years, \( \tau = -0.723 \); 70–74 years, \( \tau = -0.561 \); 75–79 years, \( \tau = -0.403 \)); the trend was increasing for the age groups above 80 years of age (80–84 years, \( \tau = 0.0193 \); 85–89 years, \( \tau = 0.258 \); 90 years or older, \( \tau = 0.386 \)).

Supplementary data, Appendix 1 available in *Age and Ageing* online provide annual number of deaths by age groups. Supplementary data, Appendix 2 available in *Age and Ageing* online show annual mortality rates per 100,000 for the whole population by 5-year age groups and the standardised mortality rate for the total population of interest. Data for males and females are available in Supplementary data, Appendices 3 and 4 available in *Age and Ageing* online; there was no significant influence of sex. Overall, mortality rates (Table 1 and Supplementary data, Appendices 2–4 available in *Age and Ageing* online) showed a decline (male, \( \tau = -0.428 \); female, \( \tau = -0.072 \); total = -0.216). Mortality rates decreased in cases aged 65–79, remained constant in cases aged 80–84 and increased in cases aged 85 or older.

Table 1 presents mechanisms of TBI-related deaths. For the whole group of 16,204 TBI fatality cases, 48% were caused by falls, 22% by traffic accidents and 17% by suicides. Women had a higher percentage of fall-related and traffic accident-related TBI deaths, and a lower percentage of suicide-related TBI deaths than men. The rate of fall-related TBI deaths increased with age while the rates of traffic- and suicide-related TBI deaths decreased with age.

### Table 1. Mechanism of fatal TBI by age groups and sex in Austrians aged 65 or older, all cases in 1980–2012

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Male</th>
<th>Traffic %</th>
<th>Fall %</th>
<th>Suicide %</th>
<th>Assault %</th>
<th>Other %</th>
<th>Total (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>65–69</td>
<td>504</td>
<td>24</td>
<td>756</td>
<td>35</td>
<td>560</td>
<td>26</td>
<td>26 1</td>
</tr>
<tr>
<td>70–74</td>
<td>543</td>
<td>24</td>
<td>834</td>
<td>38</td>
<td>558</td>
<td>25</td>
<td>8 0</td>
</tr>
<tr>
<td>75–79</td>
<td>523</td>
<td>23</td>
<td>906</td>
<td>40</td>
<td>532</td>
<td>24</td>
<td>16 1</td>
</tr>
<tr>
<td>80–84</td>
<td>322</td>
<td>18</td>
<td>846</td>
<td>47</td>
<td>404</td>
<td>22</td>
<td>7 0</td>
</tr>
<tr>
<td>85–89</td>
<td>143</td>
<td>14</td>
<td>571</td>
<td>54</td>
<td>210</td>
<td>20</td>
<td>0 0</td>
</tr>
<tr>
<td>90 or older</td>
<td>45</td>
<td>10</td>
<td>281</td>
<td>64</td>
<td>57</td>
<td>13</td>
<td>2 0</td>
</tr>
<tr>
<td>Total</td>
<td>2,080</td>
<td>21</td>
<td>1,494</td>
<td>42</td>
<td>2,321</td>
<td>23</td>
<td>59 1</td>
</tr>
</tbody>
</table>

#### Male

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Female</th>
<th>Traffic %</th>
<th>Fall %</th>
<th>Suicide %</th>
<th>Assault %</th>
<th>Other %</th>
<th>Total (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>65–69</td>
<td>291</td>
<td>42</td>
<td>217</td>
<td>32</td>
<td>91</td>
<td>13</td>
<td>25 4</td>
</tr>
<tr>
<td>70–74</td>
<td>362</td>
<td>38</td>
<td>386</td>
<td>40</td>
<td>102</td>
<td>11</td>
<td>19 2</td>
</tr>
<tr>
<td>75–79</td>
<td>413</td>
<td>31</td>
<td>675</td>
<td>51</td>
<td>87</td>
<td>7</td>
<td>31 2</td>
</tr>
<tr>
<td>80–84</td>
<td>308</td>
<td>21</td>
<td>938</td>
<td>63</td>
<td>85</td>
<td>6</td>
<td>13 1</td>
</tr>
<tr>
<td>85–89</td>
<td>151</td>
<td>13</td>
<td>849</td>
<td>71</td>
<td>48</td>
<td>4</td>
<td>15 1</td>
</tr>
<tr>
<td>90 or older</td>
<td>36</td>
<td>6</td>
<td>509</td>
<td>79</td>
<td>15</td>
<td>2</td>
<td>5 1</td>
</tr>
<tr>
<td>Total</td>
<td>1,561</td>
<td>25</td>
<td>3,574</td>
<td>57</td>
<td>428</td>
<td>7</td>
<td>108 2</td>
</tr>
</tbody>
</table>

#### Total

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Traffic %</th>
<th>Fall %</th>
<th>Suicide %</th>
<th>Assault %</th>
<th>Other %</th>
<th>Total (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>65–69</td>
<td>795</td>
<td>28</td>
<td>973</td>
<td>35</td>
<td>651</td>
<td>23</td>
</tr>
<tr>
<td>70–74</td>
<td>905</td>
<td>28</td>
<td>1,220</td>
<td>38</td>
<td>660</td>
<td>21</td>
</tr>
<tr>
<td>75–79</td>
<td>936</td>
<td>26</td>
<td>1,581</td>
<td>44</td>
<td>619</td>
<td>17</td>
</tr>
<tr>
<td>80–84</td>
<td>630</td>
<td>19</td>
<td>1,784</td>
<td>54</td>
<td>489</td>
<td>15</td>
</tr>
<tr>
<td>85–89</td>
<td>294</td>
<td>13</td>
<td>1,420</td>
<td>63</td>
<td>258</td>
<td>11</td>
</tr>
<tr>
<td>90 or older</td>
<td>81</td>
<td>7</td>
<td>790</td>
<td>73</td>
<td>72</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>3,641</td>
<td>22</td>
<td>7,768</td>
<td>48</td>
<td>2,749</td>
<td>17</td>
</tr>
</tbody>
</table>

This study analysed the long-term trend of geriatric TBI mortality in Austria 1980–2012. The Austrian geriatric population is growing and with it the number of geriatric TBI cases, which is the same for all developed countries [8, 12, 13]. The older adults are more susceptible to TBI due to reduced reactivity and mobility, and are more likely to have subsequent unfavourable outcomes of TBI due to functional changes in the aged brain [5, 7, 14]. Faul et al. [10] as well as Dams-O’Connor et al. [6] concluded that TBI-related trauma room visits among older adults in the United States are increasing at a rate that exceeds population growth. An increase in fatal TBI cases has been found in our study too; TBI mortality, however, increased in the oldest patients only (80 years or older). The average TBI mortality in adults aged 65 or older in Austria in 1980–2012 was 40/100,000 inhabitants. It is almost impossible to compare with other countries as true mortality rates in older adults with TBI are difficult to estimate due to methodological and conceptual differences of the studies [5]. However, mortality rates standardised to WHO Standard population were much higher in each of the 5-year age groups. Since the millennium, the number of cases as well as the mortality rates in the oldest age groups are on the rise. This trend is confirmed in several studies by other authors,
especially for hospitalisation rates and emergency department visits [5, 9]. As Dams-O’Connor points out, the increase in TBI-related trauma admissions will continue in the next years and decades as ‘Baby Boomers’ will enter older adulthood worldwide, thus posing a serious burden on associated medical and social services [6].

In our study, the number of fatal TBI cases in older adults caused by traffic accidents declined significantly from 232 cases in 1980 to 37 cases in 2012, despite the growth of the Austrian geriatric population (1,169,338 in 1980 and 1,512,261 in 2012). This suggests successful implementation of preventive measures. Austria enacted seat belt laws in 1984 (for front seats), and in 1990, seat belts were made obligatory on all seats in motor cars.

The most common cause of fatal TBI in the older adults is falling. The 200 fatal TBI cases due to falls in 1980 rose to a maximum of 342 in 2011. TBI-related mortality rates due to falls were highest in the age groups 80 or older. This increase has been found in other studies [11]. As the population ages, it is an urgent public health challenge to take preventive measures to stop the epidemics of traumatic brain injuries and fatalities in older adults, including by promoting maintenance of health and independence [15, 16].

**Key points**

- Trend of TBI-related mortality of total population of Australians aged 65 and older in the period 1980–2012 is decreasing.
- Trend of TBI-related mortality of Austrians aged 80 and older in the period 1980–2012 is increasing; the number of fatal TBI cases caused by traffic accidents in older Austrian adults decreased in 2012 compared with 1980.
- Number of fatal TBI cases caused by falls in older Austrian adults increased in 2012 compared with 1980.
- Rates of fall-related TBI deaths in Australians aged 65 and older in the period 1980–2012 increased with age.

**Conflicts of interest**

None declared.

**Funding**

INRO is supported by an annual grant from Mrs. Ala Auersperg-Isham and Mr. Ralph Isham and by small donations from various sources.

**Supplementary data**

Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

**References**


Functional status after critical illness: agreement between patient and proxy assessments

Amy M. Ahasic1, Peter H. Van Ness2,3, Terrence E. Murphy2,3, Katy L. B. Araujo2,3, Margaret A. Pisani1

1Department of Internal Medicine, Section of Pulmonary, Critical Care and Sleep Medicine, Yale University School of Medicine, PO Box 208057, New Haven, CT, USA
2Department of Internal Medicine, Section of Geriatrics, Yale University School of Medicine, New Haven, CT, USA
3Yale Program on Aging, Yale University School of Medicine, New Haven, CT, USA

Address correspondence to: A. M. Ahasic. Tel: (+1) 203 785 4163; fax: (+1) 203 785 3634. Email: amy.ahasic@yale.edu

Abstract

Background: assessment of baseline functional status of older patients during and after intensive care unit (ICU) admission is often hampered by challenges related to the critical illness such as cognitive dysfunction, neuropsychological morbidity and pain. To explore the reliability of assessments by carefully chosen proxies, we designed a discriminating selection of proxies and evaluated agreement between patient and proxy responses by assessing activities of daily living (ADLs) at 1 month post-ICU discharge.

Methods: patients ≥60 years old admitted to the medical ICU were enrolled in a prospective parent cohort studying delirium. Proxies were carefully screened at ICU admission to choose the best available respondent. Follow-up interviews, including instruments for ADLs, were conducted 1 month after ICU discharge. We examined 179 paired patient-proxy follow-up interviews. Kappa statistics assessed inter-observer agreement, and McNemar’s exact test assessed response differences.

Results: patients averaged 73.3 ± 8.1 years old with 29% having evidence of cognitive impairment. Proxies were most commonly spouses (38%) or children (39%). Overall, there was substantial (κ ≥ 0.6) to excellent agreement (κ ≥ 0.8) between patients and proxies on assessment of all but one basic and one instrumental ADL.