Road Collisions as a Cause of Traumatic Spinal Cord Injury in Ireland, 2001–2010

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**Background:** Road collisions remain the leading cause of traumatic spinal cord injury (TSCI) in the world. Half of all TSCIs in Ireland in 2000 were caused by road collisions. Since then, there has been a downward trend in road fatalities coincident with implemented road safety strategies. **Objective:** To examine the incidence of TSCI resulting from road collisions from 2001 to 2010. **Method:** This is a retrospective study using the hospital inpatient enquiry database of the tertiary referral center, which houses the national spinal injuries unit. Information retrieved included total numbers of patients with TSCI and number of TSCIs due to road collisions from 2001 through 2010, age groups affected, and the gender balance. **Results:** Over the 10-year period studied, the incidence rate of TSCI due to road collisions declined, although this did not reach statistical significance. The largest numbers of all TSCIs and TSCIs due to road collisions were in the 20- to 29-year age category and the male gender. **Conclusions:** As mortality due to road collisions declined, so did the number of TSCIs from the same etiology. An impactful road safety campaign is likely to have influenced these trends. **Key words:** epidemiology, road collisions, road safety, traumatic spinal cord injury

Worldwide, road collisions remain the leading cause of traumatic spinal cord injury (TSCI). Except for Eastern Europe, South Asia, and Oceania, road collisions were the most common cause of TSCI in all World Health Organization (WHO) regions from 1959 to 2008.1 In Western Europe, road collisions accounted for 46% of all TSCIs during that time period.1 TSCI due to road collision is typically associated with males younger than 30 years of age.2-5 In Ireland, the only published study of TSCI epidemiology revealed that 23 of 46 (50%) incidents in 2000 were due to road collisions.6 Of persons injured in road collisions, 24% were car drivers, 11% were car passengers, 9% were motor bike users, and 4.5% were cyclists; there was a single motor cycle passenger and a single pedestrian.6 March, May, and September were the months associated with the most TSCIs of all causes.6

In the late 1990s, the need was identified in Ireland for a strategic approach to road safety due to the high number of road fatalities. The first road safety strategy (1998 to 2002) set out the parameters for this approach that centered on the 3 main road safety interventions of education, engineering, and enforcement. The road safety strategy from 2007 to 2012 coincided with the establishment of the Road Safety Authority, a specialist agency under the auspicious of the Department of Transport. Over the last decade, there has been relative success in reducing the impact of road traffic collisions on Irish society. In 2000, there were 110 fatalities and 3,180 injuries per million population and 247 fatalities and 7,159 injuries per million vehicles registered. In 2010, these numbers had fallen to 47 fatalities and 1,850 injuries per million population and 88 fatalities and 3,423 injuries per million vehicles registered. The road safety target of no...
more than 252 deaths per year by the end of 2012 was achieved 4 years ahead of schedule, with 186 fatalities provisionally reported in 2011.

In recent years, the Road Safety Authority’s high-profile media campaigns have been supportive of interventions relating to education, engineering, and enforcement. These interventions correspond to increased resources for the Irish Police (An Garda Síochána). The Garda Traffic Corps increased to 1,200 officers (from 580) in 2008. This enforcement strategy was enhanced by legislation to reduce the legal blood alcohol level for driving from 0.08% to 0.05% and to 0.02% for novice and professional drivers, the introduction of mandatory alcohol testing (a form of random breath testing) and the addition of newer road safety offences to the penalty points system that was originally established in 2002. The use of a comprehensive safety camera initiative, which commenced in 2011, has supported An Garda Síochána in reducing speeding on Irish roads at known locations where speed has been a factor in fatal and serious injury collisions.

The education strategy for road safety targets all levels of society. Formal road safety education is now established in primary and secondary schools, at third level institutions, and at a community level, where specific programs exist for individuals not involved in formal education. The Road Safety Authority also supports educational campaigns that focus on improved driver training and testing programs, which are now being implemented in Ireland. The improvement in Ireland’s infrastructure (there are now well-designed motorways connecting the main urban and industrial regions of the country) has also contributed to Ireland’s success in improving road safety. The Road Safety Authority has developed media campaigns to inform older drivers who have not passed their driving test recently about how to safely use this improved infrastructure.

It is reasonable to assume that as the number of fatalities and injuries from road traffic collisions have fallen since 2000, so has the number of TSCIs. The objective of this study, therefore, was to examine the incidence of TSCI resulting from road collisions from 2000 to 2010, coincident with the implementation of an impactful road safety strategy.

Methods

In the acute phase, almost all TSCIs in Ireland are managed in one center, the National Spinal Injuries Unit at the Mater Misericordiae University Hospital (MMUH), Dublin. In this retrospective study, the hospital inpatient enquiry (HIPE) database of the MMUH was used to gather information on the total number of TSCIs and number of injuries sustained in road collisions from 2001 to 2010 inclusive. The HIPE database is based on the WHO’s International Classification of Diseases. The numbers retrieved from HIPE were those newly injured with TSCI who were being discharged from the MMUH and transferred to the National Rehabilitation Hospital. Our prime objective was to examine trends over the 2001-2010 decade, as 2000 has been analyzed previously.6 However, to compare changes within age groups, we included 2000, as this allows for 2 time periods of almost equal length (2000-2004 and 2005-2010).

For 2000-2004, ICD-9 was used; for 2005-2010, ICD-10 was used. In the ICD-9, codes 806 (fracture of the spine with injury of the spinal cord) and 952 (injury of the spinal cord without apparent spinal fracture) were used to identify patients with TSCI, and codes e810-825 and e829 were used to identify those injuries caused by road collisions. In the ICD-10, TSCIs were identified within code categories S14 (injury of nerves and spinal cord at neck level), S24 (injury of nerves and spinal cord at thoracic level), and S34 (injury of nerves and lumbar spinal cord at abdominal, lower back and pelvic levels); codes V02-89 were used to identify injuries caused by road collisions.

The number and incidence rate per 100,000 of population of total TSCIs and TSCIs due to road collisions were prepared for each year that the most relevant census data were available. This included the censuses of 20027 and 20068 and the census of 20119 for rates in 2010. The computation of incidence rates across time removed any changes that may have been due to an increasing or decreasing overall population size in the study timeframe. For each incidence rate, simple 95% confidence intervals were computed based on the binomial distribution and large samples, as per Merrill.10 This enabled the rates to be compared statistically. To compare changes in rates by gender,
we computed incidence rates for TSCIs due to road collisions by gender. However, due to the very small sample sizes, confidence intervals were not computed for the female rate in 2010.

Finally, to identify any changes in numbers within age groups across time, we compared the proportion of cases within relevant age bands between the first and second half of the decade. A $z$ test for the difference in incidence within each age group was conducted based on the 2-tailed null hypothesis that incidence within age groups between the periods 2000–2004 and 2005–2010 did not differ. A power analysis was conducted to ascertain whether sample sizes were sufficient to detect a statistically significant difference in 2 independent incidence rates. Based on Cohen,$^{11}$ a total of 63 cases was needed within each of the 2 groups to detect a medium (0.50) effect size or a difference in 2 incidence rates with a power of 80% ($\beta = 0.80$) and for a type I error of $\alpha = 0.05$.

Results

The total number of TSCIs in Ireland remained constant over the period from 2001 to 2010. The number of TSCIs due to road collisions, relative to the total number, is shown in Figure 1. Analysis of the basic incidence rates of all TSCIs demonstrated only minor variations between census years.$^{7-9}$ However, it can be seen within Table 1 that the incidence rate of TSCIs due to road collisions more than halved during the period from 2006 to 2010, decreasing from 0.590 to 0.240 per 100,000 of population. This reduction of 0.35 in the proportion would be considered by Cohen$^{11}$ to be statistically a small effect. Analysis of the corresponding 95% confidence intervals for the 2006–2010 period illustrates that the confidence intervals for the 2 time periods overlap; there was no statistically significant difference in the observed rates detected and the results from the power analysis were of insufficient numbers to detect a difference.

Males accounted for 69% to 85% of all patients sustaining TSCIs and for 70% to 88% of patients sustaining TSCIs due to road collisions during each year of the study period of 2001-2010. Comparing incidence rates within males and within females over the same time period revealed a similar pattern in the period of 2006 to 2010, with rates reducing by more than half. There was a practical drop in TSCIs due to road collisions among males.
and among females, but confidence intervals for the rates continued to marginally overlap; this drop in rate was not detected as statistically significant. Comparing rates across genders revealed practical and statistically significant differences in prevalence rates between males and females. These results are presented in Table 2. Mean age of patients sustaining TSCIs from all causes was 43 years (SD 3.6). Mean age of those who sustained TSCI due to road collisions was 36 years (SD 2.9). The highest incidence of TSCIs due to all causes and due to road collisions occurred in the 20- to 29-year age category, as shown in Figure 2. The age distribution of cases and the z test of incidence rates across time are presented in Table 3. None of the changes in incidence rates per age group were found to be statistically significant.

Discussion

In most countries, road collisions have been the leading cause of TSCI for several years, including Australia, Denmark, France, Greece, Italy, Japan, Nigeria, Sierra Leone, Turkey, United States, and Zimbabwe.\textsuperscript{12-20} In the United States, road collisions accounted for 48.8% of TSCIs between 2000 and 2004 and for 45.4% between 2005 and 2008.\textsuperscript{12} It was reported that road collisions accounted for 50% of TSCIs in Ireland in 2000.\textsuperscript{6} Over the period of this study, a decade during which there was implementation of a road safety strategy and a decrease in road mortality, there was a clear downward trend in the number of TSCIs arising from road collisions, although this has not been proven to be statistically significant. In Denmark, it was observed that a falling proportion of TSCIs due to road collisions coincided with the introduction of speed limits in 1973 and the compulsory use of seat belts in 1976.\textsuperscript{16} In Australia, road deaths were reduced through public health measures, including random breath testing, seat belt and helmet laws, and graduated licensing; coincident with this decline in the numbers of road deaths, there was a decline in the number of TSCIs resulting from road collisions.\textsuperscript{21} It has been suggested that a reduction in incidence of 3% per year is a realistic goal of safety strategies;\textsuperscript{21} this has been surpassed in Ireland over the past decade.

Table 1. Incidence rates of traumatic spinal cord injury (discharged from hospital) from all causes and from road collisions from 2001 to 2010

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Total no. of TSCIs</th>
<th></th>
<th></th>
<th>No. of TSCIs due to road collisions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All</td>
<td>Incidence rate per 100,000 population</td>
<td>Incidence rate, 95% CI</td>
<td>All</td>
<td>Incidence rate per 100,000 population</td>
</tr>
<tr>
<td>2002</td>
<td>3,917,336</td>
<td>55</td>
<td>1.404</td>
<td>1.033, 1.775</td>
<td>23</td>
<td>0.587</td>
</tr>
<tr>
<td>2006</td>
<td>4,234,925</td>
<td>63</td>
<td>1.488</td>
<td>1.120, 1.855</td>
<td>25</td>
<td>0.590</td>
</tr>
<tr>
<td>2010</td>
<td>4,581,269</td>
<td>58</td>
<td>1.266</td>
<td>0.940, 1.592</td>
<td>11</td>
<td>0.240</td>
</tr>
</tbody>
</table>

Note: TSCI = traumatic spinal cord injury.

Table 2. Incidence rates of traumatic spinal cord injury (TSCI) from road collisions, by gender, from 2001 to 2010

<table>
<thead>
<tr>
<th>Year</th>
<th>Population Males/Females</th>
<th>No. of TSCIs due to road collisions by gender</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males/Females</td>
<td>Incidence rate per 100,000 population</td>
<td>Incidence rate, 95% CI</td>
</tr>
<tr>
<td>2002</td>
<td>1,945,187/1,972,149</td>
<td>18</td>
<td>0.925</td>
</tr>
<tr>
<td>2006</td>
<td>2,118,209/2,116,716</td>
<td>20</td>
<td>0.944</td>
</tr>
<tr>
<td>2010</td>
<td>2,268,698/2,312,571</td>
<td>9</td>
<td>0.397</td>
</tr>
</tbody>
</table>
The failure to implement safety measures and the use of alcohol and drugs are known to be influential factors in road collisions causing TSCIs. In one study, 22% of road collision victims reported using safety measures, such as a seatbelt or a motorcycle helmet. The largest percentage of injuries resulting from nonuse of safety measures was found in the <25 age group (85%), although

![Figure 2. All traumatic spinal cord injuries (TSCIs) due to all causes and road collisions per age group, 2001-2010 inclusive.](image)

### Table 3. Incidence of traumatic spinal cord injury (TSCI) from road collisions from 2000 to 2004 and from 2005 to 2010 by age

<table>
<thead>
<tr>
<th>Age groups, years</th>
<th>TSCIs due to road collisions 2000-2004</th>
<th>Incidence rate per 100,000 population&lt;sup&gt;a&lt;/sup&gt;</th>
<th>TSCIs due to road collisions 2005-2010</th>
<th>Incidence rate per 100,000 population&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Z value&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
<td>24</td>
<td>7.66</td>
<td>13</td>
<td>4.48</td>
<td>1.566</td>
</tr>
<tr>
<td>20-29</td>
<td>41</td>
<td>6.40</td>
<td>43</td>
<td>6.01</td>
<td>-1.003</td>
</tr>
<tr>
<td>30-39</td>
<td>22</td>
<td>3.69</td>
<td>17</td>
<td>2.53</td>
<td>0.452</td>
</tr>
<tr>
<td>40-49</td>
<td>12</td>
<td>2.30</td>
<td>14</td>
<td>2.43</td>
<td>-0.758</td>
</tr>
<tr>
<td>50-59</td>
<td>8</td>
<td>1.87</td>
<td>4</td>
<td>0.85</td>
<td>0.966</td>
</tr>
<tr>
<td>60-69</td>
<td>9</td>
<td>3.13</td>
<td>4</td>
<td>1.23</td>
<td>1.199</td>
</tr>
<tr>
<td>70-79</td>
<td>1</td>
<td>0.50</td>
<td>7</td>
<td>3.31</td>
<td>-2.345</td>
</tr>
<tr>
<td>80-89</td>
<td>2</td>
<td>1.99</td>
<td>3</td>
<td>2.66</td>
<td>-0.595</td>
</tr>
</tbody>
</table>

<sup>a</sup>Based on the 2002 census of population.

<sup>b</sup>Based on the 2006 census of population.

<sup>c</sup>Value of >1.96 or <-1.96 is significant.
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in previous studies. Difficulties with data collection based on ICD codes have been reported previously; it has been suggested that the use of the ICD-9 leads to overestimation of number of TSCI cases while use of ICD-10 leads to omission. A further difficulty with our data collection method is that HIPE is not linked to the Road Safety Authority database, which is developed from police collision reports. This database includes information about the collision that would be helpful to this study, particularly regarding the vehicle type used by the injured person. A final limitation of this study is that it may not have captured all cases of TSCI in Ireland and does not include children. As in other studies, individuals who sustained TSCIs and died at the scene of trauma or in their local hospital, prior to transfer to the National Spinal Injuries Unit, were not included. Occasionally, a patient with TSCI is not admitted to the National Spinal Injuries Unit and is directly referred to the national center for spinal cord injury rehabilitation (National Rehabilitation Hospital) or, if less severely injured, he or she might recover adequately from an incomplete injury to be discharged home with nonspecialist outpatient therapy.

In Ireland, there is no national SCI registry or trauma registry. Such databases exist in Australia, Canada, and to some degree in the United States. Data collection should be less complicated in a country as small as Ireland, with one specialist acute spinal cord injury center and one specialist rehabilitation center, compared with a large country such as France where there are approximately 150 units. This study on one aspect of TSCI epidemiology reinforces the need for the development of a TSCI registry in Ireland, adhering to recommended methods of data collection, the inclusion of the International Spinal Cord Society (ISCoS) core dataset and the use of the International Classification of External Cause of Injury (ICECI), as endorsed by ISCoS and WHO.33

Conclusions

Road collisions as a cause of TSCI have reduced since 2000. Road safety legislation and awareness are very likely to have influenced this trend. The
establishment of a national TSCI registry that collects the appropriate information accurately is vital for ongoing preventive measures in the future.

Acknowledgments

Conflict of interest: The authors of this study declare no conflict of interest.

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Additional contributions: Helen Nolan, HIPE Office, Mater Misericordiae University Hospital.