WORK-RELATED SPINAL CORD INJURY
AUSTRALIA 1986-1997

Flinders University of South Australia

OCTOBER 2000
Work-related spinal cord injury
Australia 1986-1997

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October 2000

National Occupational Health and Safety Commission
Sydney
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Abstract

Little has been published in the international medical literature on the epidemiology of work-related spinal cord injury. This contrasts with the wealth of studies on return to work and employment after spinal cord injury. The imbalance in the literature perhaps reflects the levels of interest in primary prevention versus rehabilitation. As there is as yet no cure for SCI, and the level of impairment at admission to hospital is not improved substantially for the vast majority of cases after rehabilitation, it is arguable that primary prevention should receive substantially greater emphasis.

This study reports on spinal cord injury (SCI) related to work, using information from the Australian Spinal Cord Injury Register (ASCIR). All incident cases of SCI from 1986 to 1997 inclusive were considered.

Each year, work-related SCI accounted for about 13% of SCI from all traumatic causes over the period 1986-1997. The age standardised incidence rate in Australia averaged about 2 cases per million of population per annum over the period. The incidence rate may have increased.

The highest proportion of cases were aged 25-34 years, an age group that would typically expect to have the greater proportion of their working life before them. Evidence from other Australian studies suggests that the majority do not return to work after their SCI. Males predominated, which may reflect their higher prior employment levels and also the nature of the industries in which they were employed. A high proportion of the cases studied were labourers and related workers, many of whom worked in the construction and mining industry and in agriculture. Although tradespersons made up a relatively high proportion of SCI cases, some other occupation categories (ie. plant and machine operators and drivers, and paraprofessionals) with a smaller labour force had a higher rate of SCI.

Nearly half of the cases studied received their SCI due to a fall. The most frequent activity engaged in at the time of injury was ‘working on a roof, ladder or scaffold’. Motor vehicle crashes were also common and vehicle rollover was the predominant crash type. Ten percent of cases were injured on a farm. Work-related cases were two to three times as likely to be paraplegic when compared with other cases (Odd Ratio 2.6; CI=2.1 to 3.3), a finding which reflected the lower incidence of motor vehicle crashes in the work-related cases.

In Australia, work-related SCI is estimated to cost more than $25 million per annum, with a substantial proportion of this cost not being met by workers’ compensation (40% of cases did not receive compensation of any sort). It has been shown elsewhere, on numerous measures, that patients who are not eligible for compensation payments have worse outcomes.

Further detailed studies of work-related SCI are required to determine the specific preventable factors. A number of areas of further research are identified in the report.
Background

The National Occupational Health and Safety Commission study brief

Spinal cord injury (SCI) is a severe condition having substantial personal and community cost. The National Occupational Health and Safety Commission (NOHSC) expressed an interest in knowing the nature and extent of work-related SCI in Australia. The Research Centre for Injury Study, which operates the Australian Spinal Cord Injury Register (ASCIR), was commissioned to prepare a report on work-related SCI on the basis of ASCIR data. The study brief required the following issues to be addressed:

- Occupation at time of incident (preferably ASCO II)
- Industry of person (preferably using ASIC)
- Demographic information (eg. age, sex)
- Activity performed at time of incident (text description)
- Agency and mechanism of injury (NOHSC Type of Occurrence)
- Place of incident (NISU)
- Location (urban/rural)

The Australian Spinal Cord Injury Register

In 1986, a data collection on SCI was initiated by Walsh (1992), based on newly incident cases reported by the six Australian Spinal Units (see Appendix 1 for list of SUs). During its period of operation, approximately 4,000 cases of SCI from traumatic and non-traumatic causes were registered. The collection was discontinued at the end of 1991. Recognising that national reporting and continuity of registration was important, the National Injury Surveillance Unit (NISU) of the Australian Institute of Health and Welfare (AIHW) funded an external review of the needs and opportunities for SCI surveillance. The results of this review were published early in 1995 (Blumer, 1995). The report recommended that a register of SCI cases be re-established. The AIHW National Injury Surveillance Unit, now a Unit of the Flinders University Research Centre for Injury Studies, acted upon this recommendation.

After consultation with the Directors of the six Spinal Units (SUs), and piloting of a data collection method in one Unit, the Australian Spinal Cord Injury Register (ASCIR) became operational on 1 July 1995. Cases of spinal cord damage from traumatic causes, and also from non-traumatic causes (eg. from disease processes such as cancer) that were treated by the SUs, were registered. A review of hospital case notes of cases incident between cessation of the collection by Walsh and the commencement of the ASCIR (ie. cases incident from 1992 to mid-
1995) was finalised in 1999, providing full coverage of the incident population in Australia from 1986.

Australia was the first country to successfully implement a national registry of SCI (O'Connor, 1999a).

In order to facilitate national and international comparisons, the case definition that was adopted for registration of traumatic cases of SCI was the CDC clinical definition (Thurman et al, 1995):

“… a case of spinal cord injury is defined as the occurrence of an acute, traumatic lesion of neural elements in the spinal canal (spinal cord and cauda equina), resulting in temporary or permanent sensory deficit, motor deficit, or bladder/bowel dysfunction”.

The ASCIR focuses on a small set of core surveillance data items specified in a data dictionary (RCIS, 1997). The agreed data set includes the following types of information: hospital and patient identifiers, socio-demographic items, service and administrative items, and basic clinical and public health information. In order to maximise the potential for international comparisons, data items and classifications were selected, as much as possible, on the basis of international standards. The neurological level of injury and degree of impairment was coded according to the American Spinal Injury Association International Standards for Neurological and Functional Classification of Spinal Cord Injury (ASIA, 1992). The level of independence in undertaking daily life activities was measured according to the Functional Independence Measure (Hamilton et al, 1987). The injury diagnosis data was coded according to the International Classification of Disease ICD-9-CM codes (WHO, 1996). Other items in the agreed data set conformed to the Australian National Health Data Dictionary (Australian Institute of Health and Welfare, 1995) and the NISU National Data Standards for Injury Surveillance (NISU, 1995).

The emphasis of the register is on the complete enumeration of those cases discharged from a SU with a neurological deficit. Given the rarity of neurological recovery from SCI at this time, these cases can be regarded as ‘persisting cases’. The persisting cases are an important group to monitor because they are the people whose health care, welfare and other needs require ongoing management and financial support. All persisting cases would be referred to a SU, either immediately or after stabilisation at another hospital. An exception is the few cases of SCI in childhood treated at paediatric hospitals. Blumer (1995) reported that these numbered fewer than four cases per year.

Terms used in this report are defined in a glossary presented in Appendix 4.
Methods

Case selection

Prior to 1992, work-related injury cases were coded according to the place of injury (ie. workplace). From 1992 onwards, these cases were identified by both the place of injury and also by the activity at the time of injury (ie. working for income). Analysis of cases from 1992 (n=216) indicated that 98% of those injured at the workplace were either coded as working for income (92%) or, from the text description and compensation fields, were specified as working at the time (6%). The remaining cases (n=4) were all tradespersons engaged in a trade related activity at the time of injury (ie. a jockey who was riding a horse and three builders engaged in building activities). This analysis suggested that all cases coded as injured at a workplace were engaged in a work-related activity at the time. Under the assumption that the post-1992 experience also applied to the pre-1992 cases, cases were selected from ASCIR where the place of injury was a workplace and/or the activity of the person at the time of injury was coded as “working for income”. Cases involving people working around their own home or undertaking voluntary work outside the home in an unpaid capacity were excluded. Some persons who were commuting to or from work were known to have been coded as “working for income” and so would have been included in the present study. The description of the injury event indicated that ten of 41 motor vehicle occupant work-related spinal cord injury cases were travelling to or from work at the time of their injury. It is not clear to what extent spinal cord injury cases that were travelling to or from work were excluded from the study because they were not coded as “working for income”. The analysis was restricted to cases incident from 1986 to 1997 because data for 1998 and 1999 were currently being assessed for quality assurance.

ASCIR coding of data items

The analysis was restricted to the available data items.

The ASCIR conformed to Level 1 of the National Data Standards for Injury Surveillance (NISU, 1995). Occupation was coded to Australian Standard Classification of Occupations, Version I. There was no ‘industry’ specification. The available demographic information was: age, sex, country of birth, highest education level achieved, employment status, place of residence, place of injury. Activity was coded in a small number of groups, of which one was working for income, and this was used to identify work-related SCIs. Further information on activity was available from the text field describing the injury event. Agency and mechanism of injury were not coded to 'NOHSC Type of occurrence', but to ICD9CM codes for external cause (WHO, 1996). Place of incident was coded to postcode, which could be translated to urban/rural, and also to type of place (eg. home, school, mine, quarry). Clinical data was also available (eg. neurological level and completeness of SCI) and this distinguished severe and high cost cases from others (ASIA, 1992). There was also an item referring to compensation status.

Two factors detracted from the capability of ASCIR to provide some of the required information:

1. Not all data fields are completed for all cases, leading to missing data. For most items this was not a substantial problem. Tabulations were presented only for data items not having high levels of missing values. Notable exclusions were postcode of place of injury and education level.
2. The RCIS commenced management of ASCIR in 1995. Prior to this time a different data collection operated. Not all items in the earlier data collection were retained in the new collection, and the formats for a number of items had changed. In order to provide useable data from 1986 to 1997, some ASCIR items were translated into a common format with the earlier data.

**Study approach**

The study was undertaken in a number of steps.

**Step 1: Preparatory work**

Where possible, ASCIR data items were translated into a common format for data analysis.

Various checks of the data, including where necessary cross checking against the original data forms, were made to ensure valid analysis. It was found that reliable information for some variables was only available for cases incident from 1992. Where the analysis was based on a restricted data set this is made clear in the results section.

Information in text strings (eg. the injury description) was coded into various formats for tabular analysis.

**Step 2: Preliminary analysis of the data**

Tabulations and charts were produced showing time series trends and patterns in SCI occurrence by a range of variables including: demographic features, type of activity, external cause (including intent), type of place, compensation and clinical features.

Population based rates were calculated, age standardised where relevant to the 1991 Australian population. In addition, rates based on the Australian labour force (ABS, 1996) were calculated by year, age group and occupation category. The labour force analysis was restricted to cases aged 15-64 years, inclusive, to focus on the primary 'working age' group. Analysis of labour force based rates of SCI by occupation category was restricted to the period 1986 to 1995 due to changes in the coding of occupational grouping from ASCO I to ASCO II in 1996 - there was no certain mapping of occupations between the two versions.

**Step 3: Detailed analysis**

The richness of the information in ASCIR was highest in the text fields concerning the description of the injury event and reason for admission. These fields were 'mined' using keyword searches to identify specific case types that were subjected to further detailed analysis. This applied to the section of the report referring to the activity engaged in at the time of the injury.
Results

Incidence of work-related SCI

Over the period 1986-1997, an average of 32 cases of SCI occurred each year in the work place (389 in total). Each year, work-related SCI accounted for about 13% of SCI from all causes over the period. The age standardised rate of work-related SCI averaged about 2 cases per million of population per annum over the period. While the rate of occurrence was low, the severity of the injury in personal, social and economic terms is enormous.

Whilst the vast majority of these injuries were unintentional (97.9%, n=381), five were due to assaults in the workplace – all from gunshot wounds, mainly in the lower thoracic region (two at T9 and two at T11) and all resulting in complete transection of the spine.

There was one case of self-harm occurring as a result of a high fall brought about by an acute psychiatric episode; one case where the SCI was caused as a result of the medical treatment of a work-related injury; and one case of unspecified intent.

SCI trend

Over the period 1986 to 1997, the age standardised rate of SCI from all causes decreased by about 10% (16% decline for SCI that was not work-related), based on the linear regression trend (Figure 1). In contrast, the age standardised rate of work-related SCI increased by 44% over the period, based on the linear regression trend. A regression change point analysis revealed that a significant change in the slope of the trend occurred in 1995 (see Appendix 3 for details), which is the year that the prospective collection of spinal cord injury data under the ASCIR commenced.

Figure 2 presents the trend in work-related SCI with reference to the size of the Australian labour force, restricted to cases aged 15-64 years. The yearly rates were higher than presented in Figure 1, which primarily reflects the smaller denominator of labour force when compared to the total population. The finer scaling, for work-related SCI, of Figure 2 compared to Figure 1, more clearly demonstrates year to year fluctuations in the rate.

Demographic features of cases

State of residence

The highest proportion of cases of work-related SCI occurred in New South Wales, Queensland and Victoria (Figure 3). When population was considered, and the annual crude rate was averaged over the period 1986-1997 (Figure 4), the States with the highest rates were Western Australia (3.8 cases per million of population per year) and Queensland (2.5 cases per million of population per year). When the size of the labour force was considered (Figure 5), there was little change in the state rate relativities from that which was apparent in the population based rates (Figure 4). A notable exception was the relatively higher rate for the Northern Territory when compared to the other states (especially compared to the ACT) when
expressed in terms of labour force rather than total population. This reflected the smaller proportion of the population that was in the labour force in the Northern Territory.

Figure 1: Rate of SCI per million of population from work-related and other traumatic causes, Australia 1986-1997 (age standardised rates)

![Graph showing the rate of SCI per million population from work-related and other traumatic causes, Australia 1986-1997.](image)

Figure 2: Rate of work-related SCI per million labour force aged 15-64 yrs, Australia 1986-1997 (crude rate)

![Graph showing the rate of work-related SCI per million labour force aged 15-64 yrs, Australia 1986-1997.](image)

Figure 3: State of residence of work-related SCI, Australia (percentage averaged over 1986-1997)

![Graph showing the state of residence of work-related SCI, Australia.](image)
Figure 4: Rate of work-related SCI per million of population by state of residence, Australia (crude rate averaged over 1986-1997)

Figure 5: Rate of work-related SCI per million labour force aged 15-64 years, Australia (crude rate averaged over 1986-1997)
**Age and sex**

Sixty percent of the cases were aged 25-54 years, with the highest proportion, and age-specific rate, in the age group 25-34 years (Figure 6). When the size of the labour force was considered, the SCI rate was highest for 25-34 year olds (Figure 7). The labour force based rate of SCI in 55-64 year olds was above that of 35-44 year olds (Figure 7), which contrasts with the pattern of rates based on total population (Figure 6). Ninety-five percent of cases were male.

**Occupation category**

Information about occupation (Figure 8) was missing for 23% of cases (n=90). Of the cases where occupation was known (n=299), the highest proportion were labourers and related workers (33%), many of whom worked in the construction and mining industry (10%) and in agriculture (5%). Nineteen percent of cases were managers and administrators, principally farmers (13%). Nineteen percent were tradespersons, most commonly working in the building trade (8%).

Considering the size of the labour force for different occupation categories (Figure 9), the crude rates of SCI were highest for labourers and related workers (8.8/million) and managers and administrators (7.6/million). While tradespersons made up a high proportion of cases, their SCI rate (3.5/million) was lower than a number of other occupation categories that accounted for a lower percentage of cases (plant and machine operators and drivers, 4.6/million; paraprofessionals, 3.7/million).

Figure 6: Age distribution of work-related SCI, Australia (percentage, and age specific rate, averaged over 1986-1997)
Figure 7: Age specific rate of work-related SCI per million labour force aged 15-64 years, Australia (crude rate averaged over 1986-1997)

Figure 8: Occupation category of work-related SCI, Australia (percentage averaged over 1986-1997)
Figure 9: Estimated rate of work-related SCI per million labour force aged 15-64 years by occupation category, Australia (crude rate averaged over 1986-1995)

Note: Cases with missing occupation category were assigned to other categories on a proportional basis.
Factors associated with the SCI event

In addition to collecting information on the demographic features of cases of SCI, the ASCIR also collected information about factors associated with the injury event such as external cause of injury, type of place of injury, and type of activity at the time of injury. This information was relevant to an assessment of the causes and prevention of SCI.

External cause of injury

The external cause of work-related SCI is presented in Figure 10. It was evident that:

- Almost half were falls (47%), especially high falls (40%).
- Injury from striking, or being struck by, an object was common (24%).
- Transport-related injury accounted for 25 percent of cases, mostly vehicle occupants (13%).

When external cause was considered by age group, it was evident that falls predominated in each age group (Figure 11).

Activity engaged in at the time of injury

Information about the activity engaged in at the time of injury was provided in the text description of the injury event, which was reliably reported for cases incident from 1992 (n=215; Figure 12). The most common types of activity are summarised below:

- The highest proportion of cases were working on a roof, ladder or scaffold at the time of injury and their SCI was caused by a fall (21%, n=45).
- Nineteen percent were riding in a motor car or truck (n=41). Thirty-six percent of these cases were involved in a vehicle rollover; 22% in a collision with another car; 15% in an incident due to impact of their vehicle with a roadside hazard; and 10% due to loss of control of the vehicle without mention of impact with another vehicle or roadside hazard or mention of rollover (Figure 13). The remaining 17% occurred in other or uncertain circumstances while riding in a motor car or truck. Of the 15 cases that involved a vehicle rollover, three (20%) were ejected from the vehicle. In these cases it was likely that a seat belt was not worn.
- Thirteen percent were unprotected road users who were riding a motorcycle or pedal cycle or were a pedestrian (n=28).
- Eleven percent of cases were crushed while engaged in a miscellaneous activity (n=24). The total number of SCIs caused by crushing incidents was higher than this as additional cases were injured while felling a tree and loading, or unloading, a truck.
- Five percent of cases were engaged in each of the following activities: flying/parachuting (n=11), tree felling (n=10), loading or unloading a truck (n=10), and riding a horse (n=10).
Figure 10: External cause of work-related SCI, Australia (percentage averaged over 1986-1997)

Figure 11: Age distribution of work-related SCI, Australia (total case count, 1986-1997)
Figure 12: Work-related activity undertaken at time of SCI, Australia (percentage averaged over 1992-1997)

Figure 13: Crash type for work-related motor vehicle occupant SCI, Australia (percentage averaged over 1992-1997)
**Type of place of injury**

Reliable information on the type of place of injury occurrence was only available for injuries that occurred from 1992 onwards. Table 1 shows the breakdown of type of place. The main groupings are summarised below:

- Twenty six percent of cases were injured on the road.
- Eighteen percent were injured at industrial or construction sites including mines.
- Ten percent were injured on a farm (excluding the farmhouse).
- Ten percent were injured in a domestic dwelling.

**Clinical profile**

Information on the neurological level of SCI and extent of injury to the spinal cord is routinely reported by SUs.

**Neurological level of injury**

The neurological level of SCI at discharge is presented in Figure 14. The neurological level of injury was not reported for 11 cases.

Two thirds of the cases where neurological level was reported (n=255) had an injury at the thoracic, lumbar, or sacral (but not cervical) levels, with an impairment or loss of motor and/or sensory function in these segments of the spinal cord. This degree of impairment is referred to as paraplegia. With paraplegia, upper limb function is spared, but depending on the level of injury, the trunk, pelvic organs, and lower limbs may be functionally impaired.

One third of the cases (n=123) had an injury to the cord at the cervical level, resulting in impairment or loss of motor and/or sensory function in the arms as well as in the trunk, legs, and pelvic organs. This degree of impairment is referred to as tetraplegia.

The most commonly injured spinal cord segments were those at the thoracolumbar junction (T12/L1), accounting for 23% of cases, and in the cervical region at C4 to C6 (26%).

Work-related cases were two to three times as likely to be paraplegic when compared with other cases (Odd Ratio 2.6; CI=2.1 to 3.3. See Appendix 2 for details). This reflected the fact that work-related cases had a lower incidence of motor vehicle injuries, which more often involved the cervical segments of the spine causing tetraplegia.

**Neurologic category**

The overall severity of SCI is usually measured by combining the neurological level and extent of injury into four neurologic categories (complete tetraplegia, incomplete tetraplegia, complete paraplegia, and incomplete paraplegia).

Table 2 presents the counts and percentages of the 'total' for the four neurological categories of SCI. Incomplete and complete paraplegia were each three times as common as complete tetraplegia.

The external cause of injury for cases of work-related SCI is presented by neurological level in Table 3. Motor vehicle occupants most often suffered from injury to the cervical segments of the spine, resulting in tetraplegia. Unprotected road users most often suffered thoracic level injuries. High and low falls primarily resulted in thoracic level injuries. Low falls had a higher proportion of sacral level injuries than high falls.
Motor vehicle occupants and high falls cases made up the largest proportion of the most severely injured i.e., those with complete tetraplegia (35% and 31% respectively; n=18 & 16 respectively).
Table 1: Work-related SCI, Type of place (Cases count, 1992-1997)

<table>
<thead>
<tr>
<th>Type of place of injury</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic dwelling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home (includes farm house)</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>Farm-house</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Free-standing house</td>
<td>10</td>
<td>4.7</td>
</tr>
<tr>
<td>Flat, apartment, terrace house</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Other or unspecified home</td>
<td>7</td>
<td>3.3</td>
</tr>
<tr>
<td>Public Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary school</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Other or unspecified school, other institution, or public administration</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>Hospital</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Recreational or sporting venue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other or unspecified recreational area</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>Oval, field, pitch</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Stadium, arena</td>
<td>4</td>
<td>1.9</td>
</tr>
<tr>
<td>Race track (horse, motorcycle, car, etc.)</td>
<td>6</td>
<td>2.8</td>
</tr>
<tr>
<td>Road</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Street or highway (public road)</td>
<td>13</td>
<td>6.1</td>
</tr>
<tr>
<td>Freeway</td>
<td>5</td>
<td>2.3</td>
</tr>
<tr>
<td>Urban road</td>
<td>14</td>
<td>6.5</td>
</tr>
<tr>
<td>Non-urban road</td>
<td>13</td>
<td>6.1</td>
</tr>
<tr>
<td>Other or unspecified street or highway</td>
<td>11</td>
<td>5.1</td>
</tr>
<tr>
<td>Commercial or service area</td>
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<td></td>
</tr>
<tr>
<td>Trade or service area</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>Shop</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>Airport</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Bus or railway station</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Warehouse</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Other or unspecified trade or service area</td>
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<td>0.5</td>
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<tr>
<td>Industrial or construction site</td>
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<td></td>
</tr>
<tr>
<td>Industrial or construction area</td>
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<td>0.5</td>
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<tr>
<td>Construction site</td>
<td>8</td>
<td>3.7</td>
</tr>
<tr>
<td>Demolition site</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>Factory</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>Other or unspecified industrial or construction area</td>
<td>11</td>
<td>5.1</td>
</tr>
<tr>
<td>Mine or quarry</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>Underground mine</td>
<td>7</td>
<td>3.3</td>
</tr>
<tr>
<td>Open mine or quarry</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>Oil or gas extraction facility</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Other or unspecified mine or quarry</td>
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<td>0.5</td>
</tr>
<tr>
<td>Farm</td>
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</tr>
<tr>
<td>Farm (excluding farm house)</td>
<td>21</td>
<td>9.8</td>
</tr>
<tr>
<td>Other</td>
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<td></td>
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<tr>
<td>Bush, remote or undeveloped place</td>
<td>5</td>
<td>2.3</td>
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<tr>
<td>Other specified remote or undeveloped place</td>
<td>23</td>
<td>10.7</td>
</tr>
<tr>
<td>Unspecified place</td>
<td>24</td>
<td>11.2</td>
</tr>
<tr>
<td>Total</td>
<td>215</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Figure 14: Neurological level of injury for work-related SCI, Australia (percentage averaged over 1986-1997)

Table 2: Work-related SCI, Neurologic category (Case count, 1986-1997)*

<table>
<thead>
<tr>
<th>Extent of injury at discharge</th>
<th>Neurological level of injury</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tetraplegia</td>
<td>Paraplegia</td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cases</td>
<td>%</td>
<td>Cases</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Complete</td>
<td>38</td>
<td>10.1</td>
<td>126</td>
<td>33.3</td>
<td>164</td>
</tr>
<tr>
<td>Incomplete</td>
<td>85</td>
<td>22.5</td>
<td>129</td>
<td>34.1</td>
<td>214</td>
</tr>
<tr>
<td>Total</td>
<td>123</td>
<td>32.5</td>
<td>255</td>
<td>67.5</td>
<td>378</td>
</tr>
</tbody>
</table>

*excludes 10 cases where neurological level of injury was not reported and one case where both neurological level and extent of injury were not reported.
Table 3: Work-related SCI, Neurologic category (Case count, 1986-1997)\textsuperscript{a}

| External cause of injury | Tetraplegia | | Paraplegia | | | | | | | | Total |
|-------------------------|------------|----|------------|----|----|----|----|----|----|----|----|----|
|                         | Cervical   | %  | Thoracic   | %  | Lumbar | %  | Sacral | %  | Count | %  |
| Motor vehicle occupant  | 28         | 53.8 | 17         | 32.7 | 7      | 13.5 | 0      | 0.0 | 52    | 100.0 |
| Unprotected road user   | 7          | 21.2 | 18         | 54.5 | 8      | 24.2 | 0      | 0.0 | 33    | 100.0 |
| High fall               | 51         | 34.5 | 60         | 40.5 | 35     | 23.6 | 2      | 1.4 | 148   | 100.0 |
| Low fall                | 6          | 28.6 | 9          | 42.9 | 3      | 14.3 | 3      | 14.3 | 21    | 100.0 |
| Struck by object or person | 20   | 22.5 | 47         | 52.8 | 18     | 20.2 | 4      | 4.5 | 89    | 100.0 |
| Other & unspecified     | 11         | 31.4 | 12         | 34.3 | 12     | 34.3 | 0      | 0.0 | 35    | 100.0 |
| Total                   | 123        |      | 163        |      | 83     |      | 9      |      | 378   | 100.0 |

\textsuperscript{a} excludes 10 cases where neurological level of injury was not reported and one case where both neurological level and extent of injury were not reported.

Cost of work-related SCI in Australia

Walsh and DeRavin (1995) estimated that the cost of the long term care of each case of SCI ranged from approximately $602,000 for a paraplegic to $1,175,000 for a tetraplegic ($4 million for a ventilator dependent tetraplegic). On this basis, the cases of work-related SCI that have occurred over the period from 1986 to 1997 can be estimated to have generated a long-term care cost of more than $300 million in Australia in total, or in excess of $25 million per year.

Reliable information on the compensation status of SCI cases was available in the ASCIR from 1986 to 1989 and also from mid-1995. This data showed that only 60% of the work-related cases received compensation (workers’ compensation or any other compensation) for their SCI. On this basis it is can be estimated that the uncompensated cost to the community of SCI is more than $10 million per year.
Discussion

Work-related spinal cord injury is a rare event. Little has been published in the international medical literature on the epidemiology of this type of injury. A Medline search revealed only one epidemiological study focused specifically on SCI in the work force (Ekong & Tator, 1985), two studies which were more broadly focussed on the epidemiology of SCI, and made mention of work-related incidence (Tator & Edmonds, 1979; Karamemhetoglu et al, 1995), and one study which was more narrowly focussed on a specific type of work-related spinal injury (Friesen & Ekong, 1988). In contrast there has been much written about the return to work and employment of SCI cases. The imbalance in the literature perhaps reflects the levels of interest in primary prevention versus rehabilitation. As there is as yet no cure for SCI, and the level of functional loss at admission is not improved substantially for the vast majority of cases even after rehabilitation, it is arguable that primary prevention should receive substantially greater emphasis.

Each year, work-related SCI accounted for about 13% of cases of SCI from all causes over the period 1986 to 1997. Ekong and Tator (1985) found a similar result in Canada. The age standardised incidence rate in Australia averaged about 2 cases per million of population per annum over the period 1986 to 1997 (or about 4 per million of the labour force aged 15-64 inclusive). Given that the present study was focussed on injury in the workplace and/or where a person was working for income, it should be considered that the rate of SCI from work more broadly defined (eg. including a person working around their own home) would be higher.

There was a 16% decline in the age-standardised rate of SCI from non work-related causes over the period 1986 to 1997. As the ascertainment of SCI by the ASCIR is very high, this indicates a real decrease in the incidence of persisting cases. In contrast, the age standardised rate of work-related SCI increased by 44% over the period, based on the linear regression trend. Although this increase is associated with the introduction of the new data collection system (ASCIR) in 1995, which made the coding of work-related injury more straightforward, the same coding system was applied to cases from 1992 based on hospital case-note reviews in all States. Hospitals have an interest in ensuring that work-related injury is noted on the case-note as they would be expecting to retrieve health care costs from a workers' compensation scheme. Therefore the apparent increase in work-related SCI may not be an artefact of the new data collection system but may represent a real increase in incidence.

Whilst the vast majority of work-related SCIs over the period 1986 to 1997 were unintentional (97.9%, n=381), five cases were due to assault. All of the assault related SCIs were from gunshot wounds, mainly in the lower thoracic region (two at T9 and two at T11) and all resulted in complete transection of the spine. The case count was too small to determine whether there was an increasing trend from this cause. From the limited evidence available, suggesting that penetrating injury has not increased in Australasia (Sidhu et al, 1996; Civil et al, 1998), it is not expected that the number of cases of work-related SCI from assault has increased. SCI from gunshot wounds is a much more prevalent problem in the United States (Stover et al, 1995, pp 35-40).

Although rare, spinal cord injury has a profound effect on the individual and has a substantial economic cost. Work-related SCI is estimated to cost more than $25 million per annum in Australia, with a substantial proportion of this cost not being met by workers' compensation. The reasons why 40% of work-related cases do not receive compensation of any sort for their injuries have not been studied and this warrants attention. Those who have no insurance cover obviously face a more challenging future financially. In addition, it has been shown on numerous measures, that SCI patients who are not eligible for compensation payments have worse outcomes (Tate et al, 1994; DeVivo et al, 1989). In respect to transport insurance, some jurisdictions have addressed this need by implementing no-fault compensation schemes, where
all are covered (eg. the Victorian Transport Accident Commission compensation scheme). For those who are insured, there has been concern expressed that lump sum payments are often spent within a short period leaving people to rely on the welfare system. Insurers are actively lobbying for changes to the tax treatment of structured settlements to encourage people to opt for a periodic payment for the life of a claimant as an alternative to lump sum payments (MAA, 1998).

Work-related SCI is not a random event. Cases cluster in certain Australian States, demographic groups, occupation categories and work activities. The reasons for the clustering of cases is not fully understood. The size and characteristics of the labour force must be considered when assessing SCI case numbers by demographic feature. The labour force based rates of SCI were highest for labourers and related workers, and managers and administrators. Although tradespersons made up a relatively high proportion of cases, some other occupation categories (ie. plant and machine operators and drivers, and paraprofessionals) with a smaller labour force had a higher rate of SCI.

Western Australia and Queensland had the highest rates of work-related SCI per million of population and labour force. The reasons for this pattern are not clear. It could reflect State differences in the number of people working in the construction and mining industry and in agriculture, both of which are work sectors in which SCIs more frequently occur.

The highest proportion of cases were aged 25-34 years, an age group that would typically expect to have the greater proportion of their working life before them. Evidence from other Australian studies suggests that between 60% and 70% do not return to work after their SCI (Athanasou et al, 1996; Murphy et al, 1997).

Males predominate in work-related SCI, which may reflect their higher employment levels and also the nature of the industries in which they are employed.

Nearly half of the cases studied received their SCI due to a fall. Falls from roofs, ladders and scaffolding were common. Ekong and Tator (1985) found a similar result in Canada. The preventability of these events is not known.

Motor vehicle crashes were also common and vehicle rollover was the predominant crash type. Recent detailed investigation of vehicle rollovers in South Australia suggests that non-sedan type vehicles (including 4-wheel drive vehicles) have a much greater likelihood of rollover SCI than sedans (O'Connor, 1999b). Prevention of these injuries requires the removal of the conditions that initiate the rollover event, such as loose road shoulders (Fildes & Vulcan, 1995), and changes to vehicle design, such as improvement of the integrity of door latches and glazing to prevent ejection (Digges et al, 1991; Rechnitzer & Lane, 1994). In addition, improvement of seat belt design has been recommended, for example, through integration of the seat belt into the seat and the fitting of pre-tensioners (Syson, 1995) to prevent vertical movement in the event of rollover.

Ten percent of cases were injured on a farm. Tator and Edmonds (1979) suggested that elderly farmers were at high risk of SCI in Canada due to falling from lofts or being crushed by overturned tractors. Friesen and Ekong (1988) found that in a Canadian farming district, a high proportion (32%) of farming related spinal injuries over the period 1979 to 1986 were caused by tractor-mounted front-end bale loaders that were used for moving large round hay bales. All of these injuries occurred when the loader arms were raised past the horizontal plane causing the bale to roll back onto the unprotected tractor operator. In the present data series, one case of SCI from such a cause was reported. Detailed information beyond that which is routinely collected by the ASCIR would be required to further assess the causes and prevention of SCI in Australia from farming activities.

Tetraplegia was less common in work-related SCI than in other cases of SCI. Ekong and Tator (1985) found a similar result in Canada. In the present data series this finding reflected the lower incidence of motor vehicle crashes in work-related SCI.

Among the issues that warrant further attention are:
1. Further detailed assessment of the labour force based rates of SCI rates, and contributing factors.
2. The reasons why a relatively high proportion of work-related cases do not receive compensation of any sort for their SCI.
3. The specific nature of the SCIs caused by falls and the extent to which they can be prevented. This would require in-depth study at the scene of the injury and include the assessment of work practices, causal factors, injury biomechanics, first aid and retrieval measures.
4. The prevention of SCI from motor vehicle rollover.
References


O'Connor PJ. 1999b. Injury to the spinal cord in motor vehicle traffic accidents. 38th Annual Scientific Meeting of the International Medical Society of Paraplegia 1999, June 18-20, Copenhagen.
Rechnitzer, G.; Lane, J. Rollover crash study - vehicle design and occupant injuries. Monash University Accident Research Centre, Melbourne, Report No. 65; 1994.


# Appendix 1

## List of Spinal Units in Australia

<table>
<thead>
<tr>
<th>City</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perth</td>
<td>Sir George Bedbrook Spinal Unit, Royal Perth (Rehabilitation) Hospital.</td>
</tr>
<tr>
<td>Adelaide</td>
<td>Spinal Injuries Rehabilitation Unit, Royal Adelaide Hospital.</td>
</tr>
<tr>
<td>Melbourne</td>
<td>Spinal Unit, Austin Hospital.</td>
</tr>
<tr>
<td>Sydney</td>
<td>Spinal Unit, Royal North Shore Hospital &amp; Royal Rehabilitation Centre at Moorong.</td>
</tr>
<tr>
<td></td>
<td>Spinal Unit, Prince Henry Hospital &amp; Prince of Wales Hospital.</td>
</tr>
<tr>
<td>Brisbane</td>
<td>Spinal Injuries Unit, Royal Alexandria Hospital.</td>
</tr>
</tbody>
</table>
## Appendix 2

### Neurological level of injury for work-related SCI compared with other SCI

<table>
<thead>
<tr>
<th>Type of SCI</th>
<th>Neurological level of injury</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tetraplegia</td>
<td>Paraplegia</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Work-related</td>
<td>123</td>
<td>7.8</td>
</tr>
<tr>
<td>Not work-related</td>
<td>1453</td>
<td>92.2</td>
</tr>
<tr>
<td>Total</td>
<td>1576</td>
<td>100.0</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Type of SCI</th>
<th>External cause</th>
<th>Neurological level of injury</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tetraplegia</td>
<td>Paraplegia</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Work-related</td>
<td>Motor vehicle occupant</td>
<td>28</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>95</td>
<td>6.0</td>
</tr>
<tr>
<td>Not work-related</td>
<td>Motor vehicle occupant</td>
<td>605</td>
<td>38.4</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>848</td>
<td>53.8</td>
</tr>
<tr>
<td>Total</td>
<td>1576</td>
<td>100.0</td>
<td>1405</td>
</tr>
</tbody>
</table>
Appendix 3

Results of regression change point analysis

In order to determine whether there was a change in the slope of the trend line for work-related SCI at a point in time, a regression change point analysis was applied to the age standardised rate data. This involved fitting separate linear regressions of the rates on year, with different cut-points allowed for in the separate regressions. That is, two separate lines were fitted with the slope allowed to change in 1987, then a separate regression was fitted in which 1988 was taken as the cut-point, then 1989 was used and so on. The cut-point that minimised the residual mean square was 1986-94 versus 1995-97.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>R</th>
<th>ANOVA Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model</td>
<td>Sum of Squares</td>
</tr>
<tr>
<td>1986-94 vs 1995-97</td>
<td>.86</td>
<td>Regression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Residual</td>
</tr>
</tbody>
</table>
Appendix 4

Glossary

**Extent of SCI:** refers to the extent of neurological damage, which is either ‘complete’ or ‘incomplete’. “If partial preservation of sensory and/or motor functions is found below the neurological level and includes the lowest sacral segment, the injury is defined as incomplete”.

The term ‘complete injury’ is used when there is an absence of sensory and motor function in the lowest sacral segment.

**Neurological level of SCI:** refers to “the most caudal segment of the spinal cord with normal sensory and motor function on both sides of the body” (ie. the lowest level that has full function).

**Newly incident case of SCI:** a person who suffers an SCI, as defined by the CDC clinical definition, during this reporting period (ie. in 1998/99).

**Paraplegia:** refers to “impairment or loss of motor and/or sensory function in the thoracic, lumbar or sacral (but not cervical) segments of the spinal cord, secondary to damage of neural elements within the spinal canal”.

**Persisting case of SCI:** a person who is discharged from a SU with a neurological deficit.

**Prevalent population:** people who have an SCI, as defined by the CDC clinical definition, at a given point in time.

**Roadside hazard:** “any fixed object by the side of the road that, by virtue of its structure and placement, results in, or is likely to result in, an increased probability of vehicle damage, occupant injury or fatality in the event of a motor vehicle leaving the roadway. Such hazardous fixed objects include trees, utility poles, luminaire supports, sign posts, bridge rails and end treatments, fences, embankments and cuttings, ditches, guard rails (and guard rail end treatments), mail boxes and drainage structures (culverts, for example)”.

**Tetraplegia:** refers to “impairment or loss of motor and/or sensory function in the cervical segments of the spinal cord due to damage of neural elements within the spinal canal”. This term is etymologically more accurate than ‘Quadriplegia’, combining tetra + plegia, both from Greek, rather than quadri + plegia, a Latin/Greek amalgam. It is generally preferred outside the US.

**Unprotected road users:** refers to pedestrians, pedal cyclists and motor cycle riders.

**Work-related SCI:** refers, in the present study, to cases selected from ASCIR where the place of injury was a workplace and/or the activity of the person at the time of injury was coded as “working for income”.

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