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Introduction

The prevention and control of injury is one of four National Health Priority Areas (AIHW & DHFS, 1997a; AIHW & DHFS, 1997b). One of the performance indicators for this priority area is the annual incidence rate of spinal cord injury from traumatic causes. The Australian Spinal Cord Injury Register (ASCIR), established in 1995, enables the patterns and trends in SCI to be monitored. Australia was the first country to implement a national registry of SCI (O'Connor, 1999a).

In order to facilitate national and international comparisons, the case definition that has been adopted for the registration of traumatic cases of SCI in Australia is the US Centers for Disease Control (CDC) clinical definition:

"... 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" (Thurman et al, 1995a).

This report presents statistical information on new cases of spinal cord injury (SCI) from traumatic causes that occurred during 1998/99 in Australia to Australian residents. In addition, SCI to overseas visitors is assessed, particularly with respect to an expected increase in the year 2000 due to Olympics related tourism. Survival from SCI is also discussed for the first time in this issue of the Bulletin, and will be reported further in the next issue on SCI.

This is the fourth annual statistical report based on data from the ASCIR. The previous reports, based on annual data from 1995/96 to 1997/98, were published in the Australian Injury Prevention Bulletin (O'Connor & Cripps, 1997; Cripps & O'Connor, 1998; O'Connor & Cripps, 1998). Terms used in the report are defined in the Glossary.

The ASCIR is now in its fifth year of operation and has nearly nine thousand cases registered, about 4,000 of which originated from a data collection that operated from 1986 to 1991.

Overview of spinal cord injury from traumatic causes

The spinal units (SUs) reported three hundred and two new cases of SCI from traumatic causes in 1998/99, of which 37 had suffered no neurological loss at admission and/or discharge. The SU Directors confirmed complete enumeration of cases. However, at the time of production of this report complete discharge details were not available for all newly incident cases, especially for those that remained on ward. The decision was therefore made to report on the 265 new cases on the basis of admission data, excluding cases known to have no neurological loss. Assessment of data from previous years indicated that there was very little difference between statistics based on admission and discharge data (for example, for 1997/98 coverage varied by only 0.38% when based on admission data rather than discharge data). Statistics from this report can therefore be readily compared with those from previous reports which were based substantially on discharge data.

Trend in SCI

The age adjusted incidence rate of SCI in 1998/99 was estimated to be 14.5 per million of population, a small decrease from 1997/98 (15.2 per million of population). The 1991 Australian population has been used as the standard population for the calculation of age adjusted rates. The case count (n=265) was the second highest recorded over the nine year period for which reliable annual data was available, being 22 cases higher than the average yearly figure for the combined years 1986-1990 and 1995/96-1997/98 (average=243 cases per year) and 13 lower than the highest case count, which occurred last year.

Figure 1 shows the age adjusted rate of SCI for 1998/99 with the rates for earlier years. Whilst there have been slight year to year fluctuations in the rate of SCI over the period, the trend line has no discernible slope ie. SCI is neither increasing or decreasing in incidence. Given that road crashes are the cause of about half of all cases of SCI, and fatalities from this cause have declined by about half over the period (FORS, 1998), it is surprising that SCI has not declined. Improved retrieval, early management and rehabilitation of the victims of road crashes, may have decreased fatalities but increased the number of severely injured survivors - an hypothesis which is currently being assessed by the Research Centre for Injury Studies (RCIS).

Although the importance of SCI has been recognised through its selection as one of the health sector indicators for injury prevention and control, no target has yet been set for its reduction. The ASCIR data should be used to assist in defining an appropriate target. It is recognised that much of the required prevention activity may not be central to the health sector. For example, the modification of the design of motor vehicles is controlled by the transport sector (through the Technical Liaison Group, Federal Office of Road Safety and National Road Transport Commission).

State of usual residence

Figure 2 shows the age adjusted rate of incidence of SCI from traumatic causes by state of usual residence.

- It was evident from the 95% confidence intervals on the rates, based on the Poisson distribution, that there were no significant differences in the State rates in 1998/99.
- Victoria has had the lowest rate of SCI over the period 1995/96 to 1998/99 (not significantly different, statistically, from the national rate in any individual year).

Overseas visitors

The Federal Office of Road Safety, in a recent report of the projected impact of the Sydney Olympics on road injury, indicated that 4.6 million tourists will visit Australia in the year 2000 (FORS, 1999). They calculated that tourists have two times the road fatality risk of Australian residents, and estimated that road deaths and serious injuries are set to increase, by 70 and 1,000 respectively, due to Olympics related tourism. It can therefore be expected that tourist SCI will also increase in the year 2000.

Tourists have twice the rate of SCI compared to Australian residents. In 1998/99 there were six cases of SCI involving tourists, arising from motor vehicle accidents (2), aquatic activities (3) and a fall. Considering that the three million tourists spend an average of 24 days in Australia (FORS, 1999), their SCI rate for this period is two per million. This compares with approximately one per million for Australian residents over the same time period (ie. Annual SCI rate of 14.5 divided by 15.2 periods of 24 days in a year).

Based on a 50% increase in tourism due to the Olympics (FORS, 1999), and a conservative assumption that length of stay in Australia will not increase, tourist SCI is set to increase to nine cases in the year 2000.

Age and sex distribution

The age distribution of SCI from traumatic causes is presented in Figure 3. The age group of 0 to 14 years was excluded from the figure because of a suspected poor coverage of this group by SUs. Most of these cases would be treated at paediatric hospitals and would be small in number. The reporting of these cases to ASCIR should be investigated, resources permitting.

From Figure 3, it was evident that:

- The highest case count, and age specific rate, occurred in the age group 15–24 years. With increasing age, the age specific rate declined substantially to the age group 45–54 years, after which it increased moderately. The most substantial decline in the case count and rate occurred from age group 35–44 years to 45–54 years.

- The wide confidence intervals on the rates (95% confidence intervals on the rates, based on the Poisson distribution) reflect the small case count for individual age groups. When age groups 15-24 years, 25-34 years and 35-44 years were combined it was evident that the rate for this group (21.5 per million of population) was significantly higher, statistically, than the rate for the older combined age group of 45 years and above (13.1 per million of population).

Of the cases of SCI from traumatic causes aged 15 years and above, 76 percent were male and 24 percent were female. The incidence of SCI by age group and sex, presented in Figure 4, shows the following:

- A higher rate of SCI for males at all ages except for the age group 45-54 years and those over 65 years of age (statistically significant).
- A substantial sex difference in a number of the age groups. The male to female rate ratios ranged from a low of 0.9:1 (in the age group 75 plus) to a high of 8.5:1 (in the age group 55–64 years).

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, role of human intent, type of place of injury, and type of activity at the time of injury. These factors, which were coded in ASCIR according to the National Injury Surveillance Unit (NISU) National Data Standards for Injury Surveillance (NDS-IS)⁸, provide useful information for understanding the causes and prevention of SCI (NISU, 1995). Supplementation of this data with other information from special in-depth investigations and data linkage is often required to gain a more detailed account of these injuries (O'Connor, 1999a).

External cause of injury

The external cause of injury for cases of SCI from traumatic causes is presented in Figure 5. It was evident that:

- Transport related injury accounted for forty three percent of the cases of SCI (n=113). Twenty-eight percent were motor vehicle occupants (n=74) and fifteen percent were unprotected road users (n=39). Eighty-five percent (n=96) of the cases of transport related SCI were aged 15–44 years.
- Twenty-three percent (n=61) were from high falls (drop of 1 metre or more) and eight percent (n=22) were from low falls. Eighty-two percent (n=18) of the low falls cases were aged 55 years or older.

Motor vehicle occupants

Further assessment of the cases that were occupants of motor vehicles (n=74), using the text description of the injury event provided on the ASCIR registration form, revealed that:

- 42 percent were due to vehicle rollover;
- 23% were due to collision with a roadside hazard (ie. tree, pole or other fixed object);
- 7% were due to ejection from the motor vehicle;
- and 30% were due to other collisions (Figure 6).

These results are generally consistent with others reported in the scientific literature (Cushman et al 1991; Huelke et al 1977, 1981, 1985; Huelke & Compton, 1983; Kraus et al 1982; Thurman et al 1995b; Toscano, 1987). The prevention measures that have been emphasised in the literature include improvement of road engineering and vehicle design (eg. sealing of road shoulders and improvement of roof crush strength and window strength), to prevent vehicle rollover and ejection, and removal of roadside hazards (Corben 1997; Kloeden et al 1999).

The information available in the ASCIR concerning SCI in road crashes can be substantially extended by linking it with Police data on crash circumstances, as was recently undertaken for South Australia (O'Connor et

al, 1999). This enables crash factors (eg. vehicle, environmental and human factors) to be assessed in relationship to injury and outcome type (eg. neurological level and extent of SCI). A better understanding of the causes of SCI, through research such as this, leads to better prevention. The study by O'Connor et al (1999) showed that SCI from vehicle rollover was much less likely in sedan type vehicles than other vehicles, such as four wheel drive vehicles, vans and utilities. Further research is required to focus in on the specific vehicle characteristics that raise the likelihood of SCI.

Falls in the elderly

The leading cause of injury death and hospitalisation in the elderly (ie. those aged 65 years or older) is falls (Harrison & Dolinis, 1995; Fildes, 1994). In 1998/99 a third of all falls related SCIs, and more than two thirds of low falls SCIs, occurred to elderly persons (ie. those aged 65 years or older).

Fracture of the lower limbs and hip is a frequent outcome of a fall (Fildes, 1994). It would appear that different mechanisms are involved in these types of injuries and falls related SCIs. In the elderly in 1998/99, 15 of the 16 low falls SCIs involved tetraplegia. Involvement of the cervical segments of the cord suggests that a head impact was involved (specific mention of a head impact was made on the registration form for more than half the cases). While considerable attention has been directed at the prevention of lower limb and hip fractures due to falls (Fildes 1994), little attention has been directed at the specific prevention of SCI. Different prevention strategies may be required to prevent falls related SCIs. Unfortunately, little is known about the circumstances of fall related SCI. The information in the text description of the injury event provided on the ASCIR registration form is insufficient for this purpose. Considering the high cost of SCI in personal and economic terms, there is ample justification for a detailed study of the causes and prevention of these events.

Place of injury

The road environment was the primary place of SCI for those aged 15-34 years (Figure 7). In this age group aquatic environments also featured prominently. A similar number of cases of SCI occurred at commercial and industrial sites in each of the age groups up to age 74 years. The home was the principal place of SCI for those aged 55 years and older.

Further assessment of the cases that suffered their SCI in an aquatic environment (n=23), using the text description of the injury event provided on the ASCIR registration form, revealed that:

- seven were surfing or swimming and were dumped by waves;
- six were diving into swimming pools;
- six were diving, or fell, into a river or lake;
- three were entering the surf, dived into the water and hit their head on the sand/sand-bar;
- and one case had another specified event (Figure 8).

Over the last four years, an average of 21 new cases of SCI have occurred each year in aquatic environments. The information available on the circumstances of these injuries is limited in ASCIR, but could be extended through supplementary in-depth investigation of the registered cases, for example, by using data available to Surf Life Saving Australia which investigates the circumstances of injury on beaches patrolled by their members.

A review of the international literature suggests that: bodysurfing is particularly hazardous for healthy middle aged men, especially those endowed with a narrow spinal canal (Cheng et al, 1992); the mechanism of SCI from bodysurfing is primarily one of forced hyperextension of the head and neck from contact of the head with the ocean floor (Scher, 1995); the consumption of alcohol is a contributing factor in half the cases of swimming pool related SCIs (DeVivo & Sekar, 1997); most of the swimming pool SCIs occur in less than one and a half metres of water (Blanksby et al, 1997); and warning signs about shallow water or sand-bars are rarely present (DeVivo & Sekar, 1997). As there are two to three cases of SCI each year in Australia that can be attributed to the presence of sand bars, with impact upon first entry to the water, there may be a need to post signs on affected beaches and to consider the potential for such an injury when determining the location of flags on beaches to delineate the area patrolled by surf lifesavers.

Diving technique has been shown to affect impact velocity and the angle of entry to the water, both of which affect the rate of deceleration upon entry to the water and the likelihood of the head contact with the bottom (Blanksby et al, 1997). However, consideration of the optimal depth of water for diving needs to be based on the range of diving techniques of members of the general public, most of whom have never been taught how to dive properly. It is generally the untrained member of the public, often in a party situation (DeVivo & Sekar, 1997) that is injured in a diving accidents rather than the trained diver. A review of the scientific literature failed to reveal any studies of the actual diving behaviour and other risk factors of the untrained public. Such a study might have implications for the design and use of swimming pools and other aquatic environments. As there are underwater viewing portals at many pools the frequency of near misses and head contacts could be studied by videotaping natural behaviour and taking supplementary measurements to determine human and environmental risk factors.

Type of activity when injured

Most of the cases were undertaking some form of leisure activity (n=108, 41%) or domestic activity (n=22, 8%) when they suffered their SCI. Twelve of the cases (5%) were engaged in a sporting activity. Of the remaining 123 cases, most of whom were engaged in 'other and unspecified' activities, 48 (18%) were working for income.

Further assessment of the cases that suffered their SCI while working for income (n=48), using the text description of the injury event provided on the ASCIR registration form, revealed that:

- 23% were driving a motor vehicle;
- 19% were felling trees, and either fell from a tree or were crushed by falling branches or the tree itself;
- 19% fell from a roof, ladder or scaffolding;
- 17% fell whilst engaged in some other work activity;
- 15% were unloading and were crushed by a falling load;
- and the remaining 8% were engaged in some other type of work activity (Figure 9).

At admission, only 27 of the 48 people injured at work (ie. 56%) were reported to be eligible for some form of compensation payment through an insurance scheme. Of the 11 people involved in a motor vehicle accident while working, all of whom were vehicle occupants and would normally be expected to be covered by motor vehicle third party insurance, two were considered to be non-compensable (one was not wearing a seat belt and the other was shot in the back in an act of violence rather than in a vehicle collision) and one was considered to have an unclear compensation status due to the fact that alcohol was involved. The general public may not appreciate that in the event of an injury while at work or in a motor vehicle crash, where insurance cover is expected, they may not be fully covered or covered at all if personal negligence is involved or the nature of the event does not fit within the specific terms of the insurance cover. Those who have no insurance cover obviously face a more challenging future financially. Some jurisdiction 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, 1999).

Tree felling would appear to be a hazardous occupation for SCI. It would be expected that the time exposure of tree felling (or the population of tree fellers) would be substantially lower than the time exposure of motor vehicle driving (or the population of drivers) and yet these occupational activities account for a similar proportion of the annual cases of SCI. A review of the circumstances of these events could reveal work practices that could be improved.

In order to determine the preventable factors of work-related SCI, data further to that already collected by the ASCIR would be required. For those who are insured, much of the data required might already be collected for the purposes of the insurance claim, and this could be analysed in the first instance. The need to contain insurance costs has encouraged insurers to invest in injury research and prevention.

Clinical information

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

Neurological level of injury

The neurological level of SCI at admission is presented in Figure 10. The most commonly injured spinal cord segments were: the cervical segments, particularly C4 (18%, n=47), C5 (17%, n=45), and C6 (9%, n=25); the lumbar segment L1 (11%, n=30); and the lower thoracic segment T12 (6%, n=17).

Neurologic category

The overall severity of SCI is usually measured by a combination of the neurological level and extent of injury into five neurologic categories (complete tetraplegia, incomplete tetraplegia, complete paraplegia, incomplete paraplegia, and complete recovery). Table 1 presents the counts and column percentages for the four neurological categories of SCI, as well as a finer breakdown of the paraplegia category.

- Fifty-eight percent of the cases (n=153) 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.
- Forty-two percent (n=112) 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.
- The most common neurologic category was incomplete tetraplegia (38% of total, n=101), followed by incomplete paraplegia (24% of total, n=64), complete paraplegia (18% of total, n=48), and complete tetraplegia (19% of total, n=51).
- Complete injury was most common in the thoracic spinal segments, a finding which is explainable by the smallness of the spinal canal in this region in relation to the size of the cord (Bauer & Errico, 1991; Bohlman, 1985; Bohlman et al, 1985; White & Panjabi, 1990).

The external cause of injury for cases of SCI from traumatic causes is presented by neurological level in Table 2.

- Motor vehicle occupants most often suffered from injury to the cervical segments of the spine, resulting in tetraplegia, with incomplete damage to the cord being most common at this level (63%, n=33).
- Unprotected road users most often suffered thoracic level injuries, which generally involved complete damage to the cord (60%, n=12).
- Low falls primarily resulted in cervical level injury and most of these involved incomplete damage to the cord (84%, n=16).
- Fifty-seven percent (n=16) of the high falls tetraplegia cases suffered complete damage to the cord whereas sixty-four percent (n=21) of the high falls paraplegia cases suffered incomplete cord damage. There was a higher frequency of complete cord damage in high falls compared to low falls, which is probably explained by the higher energy of the high fall impacts.

Motor vehicle occupants and high falls cases make up the largest proportion of the most severely injured ie. those with complete tetraplegia (35% and 31% respectively; n=18 & 16 respectively). Arguably, the prevention of these injuries is of highest priority.

Survival after SCI

An international first

There have been only two studies of survival from SCI conducted in Australia (Yeo et al, 1998; Sneddon & Bedbrook, 1982). Neither was based on a defined population and neither was national in scope. There has been only one SCI survival study in the world that was national in scope, but that was restricted to a veteran population (Samsa, 1993). Australia is one of the few countries that have a national population based register of SCI, providing the opportunity for the first national survival study of a non-veteran community (O'Connor, 1999b). The aims of this study are (1) to determine survival from SCI in a national population, and (2) to help to prevent premature death by identifying the leading causes and some of their risk factors. The ASCIR has been linked with the Australian National Deaths Index (NDI) to determine which members of the SCI population have died, when they died and what caused their death. The NDI is a database, housed at the Australian Institute of Health and Welfare, which contains records of all deaths occurring in Australia since 1980. The data are obtained from the Registrars of Births, Deaths and Marriages in each State and Territory.

The results of the study will be reported in a future issue of the Bulletin. In this issue, a review of the international literature is summarised.

A review of the international literature

The results of the most often cited studies of survival after SCI are summarised in Table 3.

Toward the end of World War II the acute mortality rate from SCI reportedly declined to approximately 20% (Poer, 1946; Barber & Cross, 1952). Whiteneck et al. (1992) contrast the median survival for those injured during the 1940's (26 years) with those injured in the 1960's (33 years). These changes were reported to be largely due to the availability of penicillin, sulfa drugs and whole blood (DeVivo et al., 1987).

Despite the substantial number of studies of survival from SCI since that time, it is difficult to determine the extent of further improvement due to substantial differences in the study methods employed. Referring to Table 3, the following differences are evident:

- Different injury and follow-up periods. Follow-up period is not specified in some articles. There seems to be no uniformity as to the time interval that constitutes the acute phase following injury. Studies focus on deaths after one day, two weeks, three months, one year or eighteen months.
- Different populations ie. different countries, different selection criteria, veterans vs. general population, restriction to survival periods that vary from study to study, and losses to follow-up.
- Some studies were based on small case series.
- Different survival parameters, especially variation in the cumulative survival period reported.
- Results reported for different groups and time periods, confidence intervals not often reported, and there was generally a failure to stratify the results by important prognostic factors such as age and level and completeness of injury.
- Relative survival was not always provided, making it difficult to compare the results of the different countries which have different survival rates in the general population.
- Few of the studies were population based and only one was national in scope, but restricted to veterans.

Given these differences it is not surprising that interpretations of the literature vary.

DeVivo et al. (1992b) found an increase, not statistically significant, in the Year 2 survival percentage from 90.0% in 1973-77 to 94.1% in 1984-86. DeVivo et al. (1992a) found an increase in cumulative seven year survival from 86.7% in 1973-80 to 89.2% in 1973-84. One of the most recent studies (Hartkopp et al., 1997a) found a 10% increase in the 10 year survival probability for men and 21% increase for women between cases injured in 1953-71 compared with 1972-90, although a corrigendum (Hartkopp et al., 1997b) raised doubt over

these figures. Comparing their results with those of Geisler (1983) a decade earlier, McColl et al. (1997) found an increase in total life expectancy of nearly five years, a result which they suggest is similar to that found by Whiteneck et al. (1992). However, for the reasons already discussed, it is difficult to be sure of the extent of improvement in survival.

The studies reported in Table 3 suggest that the 20-25 year survival of SCI cases could range from about 70% to 90% of that of the general population whilst the 40 year survival could be about 70% (based on the experience of veterans). However, this assessment is based on the small number of studies that have reported relative survival or have presented data that enables it to be estimated.

There are a number of factors that have been consistently shown to be predictors of mortality for the SCI population. Age at injury and year of injury are two such factors. Those injured at younger ages and those injured more recently experience better survival outcomes (McColl et al., 1997; Whiteneck et al., 1992; Samsa et al., 1993; Hackler, 1977; Kiwerski, 1993). Neurological level and completeness of injury have also been found to be important predictors of mortality (McColl et al., 1997; Whiteneck et al., 1992; Hackler, 1977; Kiwerski, 1993). Early mortality for those aged 50 or more years with complete cervical cord injury is very high. Alander et al. (1994) found a 60% within the first four months. The intermediate-term outcome for this group was also poor, with only 13% surviving the first year (Alander et al., 1997). Those with incomplete injuries had a better outcome in the intermediate-term, with 93% surviving the first year, but only 50% survived to 5.5 years (Alander et al., 1997).

Changes in medical practice from the early 1970s have brought about a significant change in the causes of death. Prior to that time renal failure was the primary cause of death (Breithaupt et al., 1961; Freed et al., 1966; Jousse et al., 1968). Substantial decreases in respiratory and renal diseases have occurred since that time (Kraus et al., 1979; Geisler et al., 1983; DeVivo et al., 1989). Whiteneck et al. (1992) observe that whilst genitourinary disorders accounted for 43% of deaths occurring in the 1940s and 1950s, they accounted for only 10% of deaths occurring in the 1980s and 1990s. Geisler (1983) speculated that advances in the fields of antibiotics, renal dialysis and in medical and surgical expertise contributed to the decline in these diseases.

As the survival of the SCI population approaches that of the general population, the causes of death also appear to be approaching those of the general population (Samsa, 1993; Whiteneck et al., 1992). However, the illnesses that cause death occur at younger ages in the SCI population (Whiteneck et al. (1992)). Also many of the cause specific death rates for SCI remain substantially above the normal population, particularly for infections, primarily septicaemia and pneumonia (Hartkopp et al., 1997; DeVivo et al., 1993; Samsa et al., 1993), but also for pulmonary emboli and suicide (DeVivo et al., 1991; Charlifue & Gerhart, 1991; Hartkopp et al., 1997a, 1997b). Hartkopp et al. (1997a) found that there was a high percentage of deaths due to lung disease, especially pneumonia, amongst those with functionally complete tetraplegia (76%).

The problems of an aging SCI population have only recently begun to be studied and addressed. Only a few studies of long-term survival (greater than 20 years) have been published. McColl et al. (1997) questions whether as survival increases, mortality continues to be compressed into the last few years of life or whether morbidity expands to fill the increased survival period. Their study of health expectancy favours the more optimistic view. Whiteneck et al. (1992) emphasise the difficulty in separating the effects of age from the effects of chronic disability in individuals who are experiencing both simultaneously. The inherent confounding of these factors makes analysis complicated.

These are some of the issues that the Australian survival study will address.

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Figures and Tables

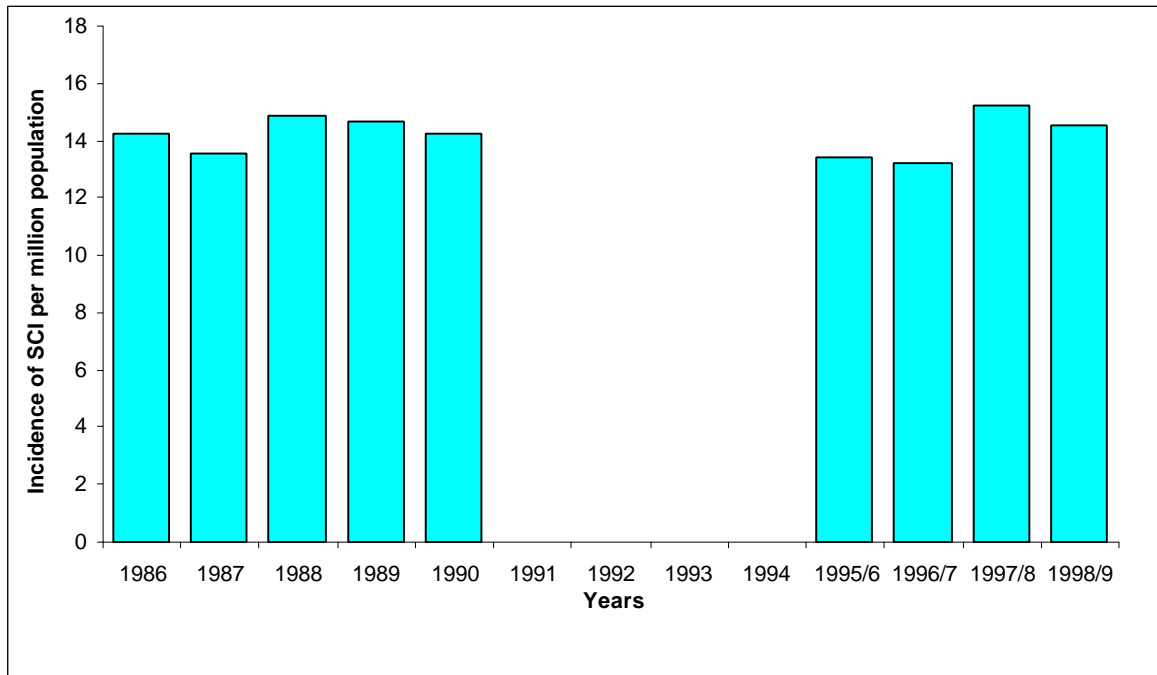


Figure 1: Incidence of SCI from traumatic causes by year, Australia 1998/99 (age adjusted rates)

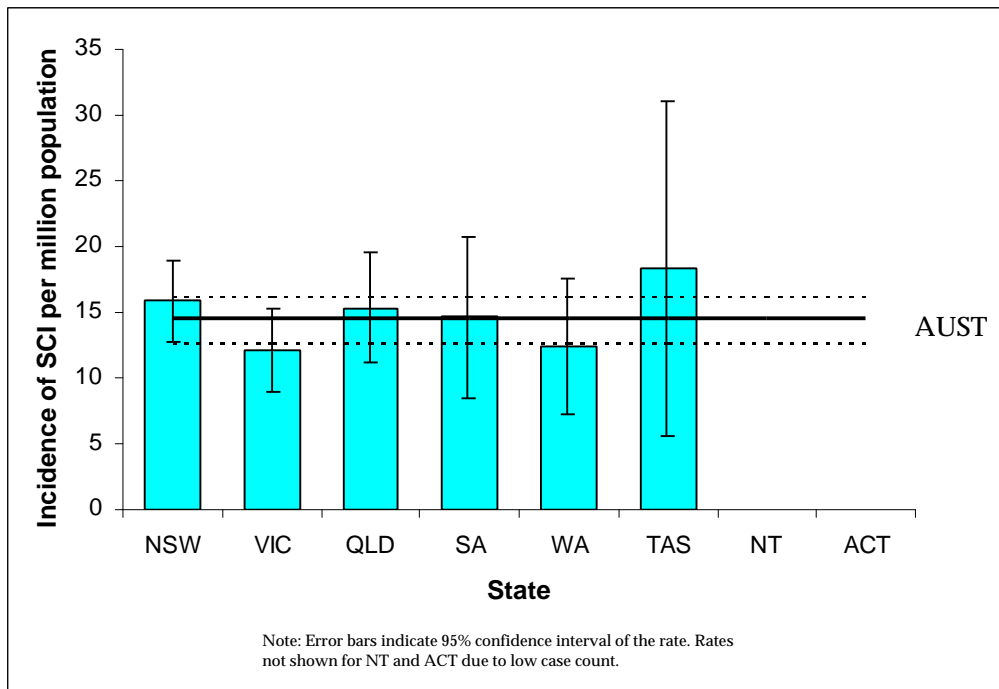


Figure 2: Incidence of SCI from traumatic causes by State of residency, Australia 1998/99 (age adjusted rates)

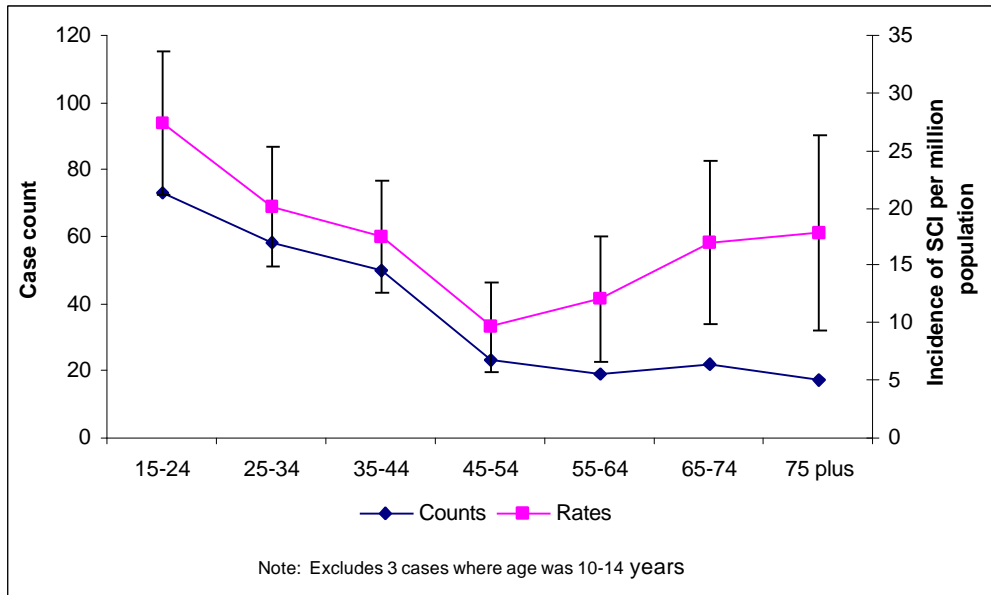


Figure 3: Incidence of SCI from traumatic causes by age group, Australia 1998/99 (counts and age specific rates)

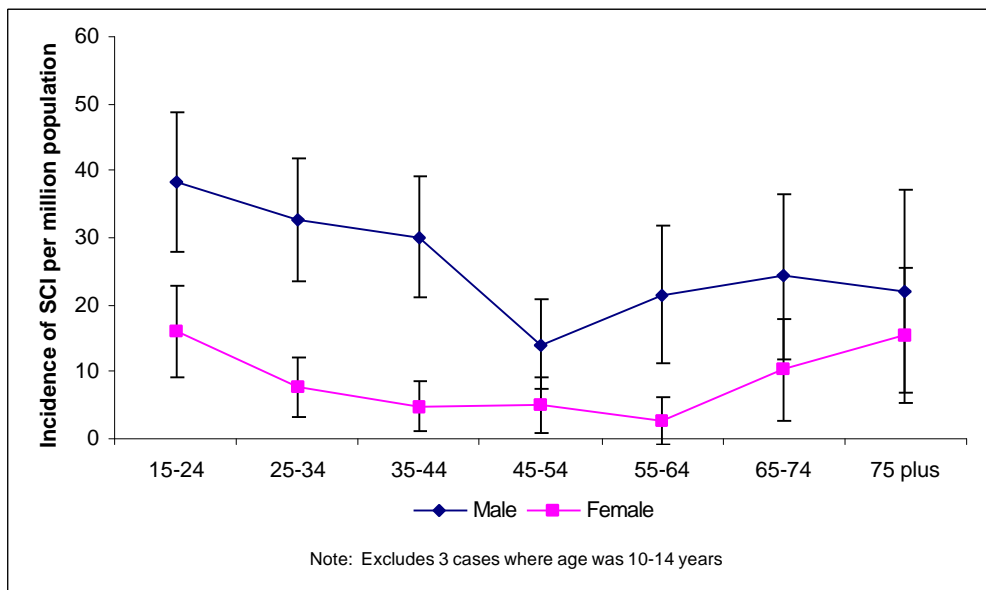


Figure 4: Incidence of SCI from traumatic causes by age group and sex, Australia 1998/99 (age specific rates)

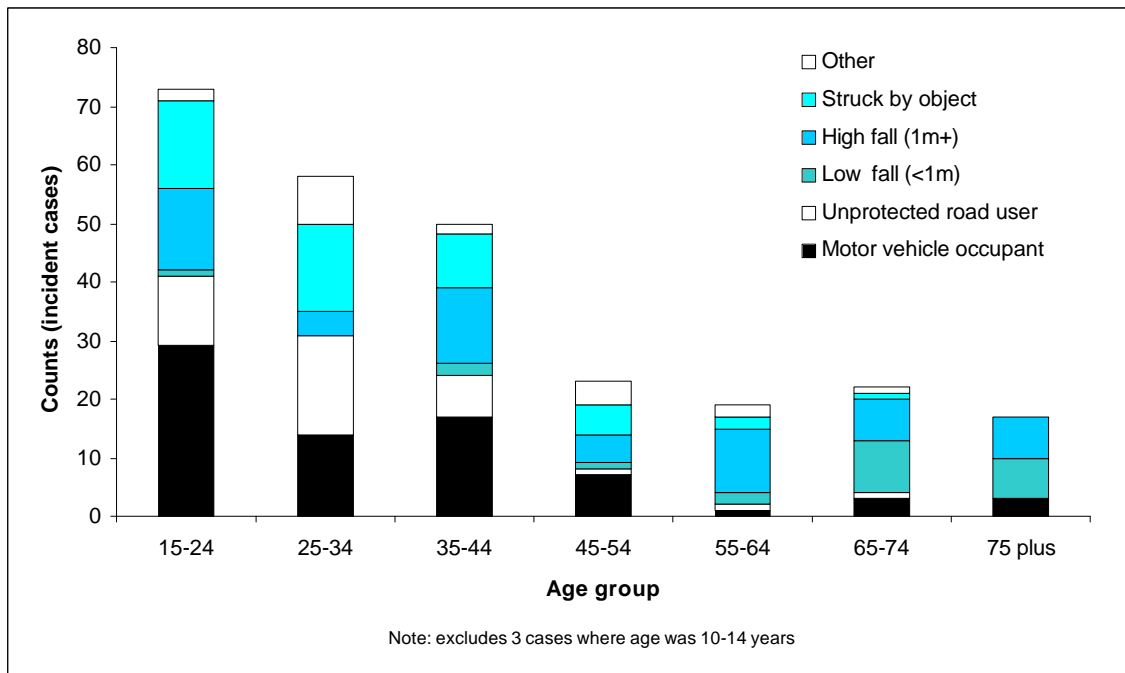


Figure 5: Incidence of SCI from traumatic causes by external cause of injury (major groupings) and age group, Australia 1998/99 (counts)

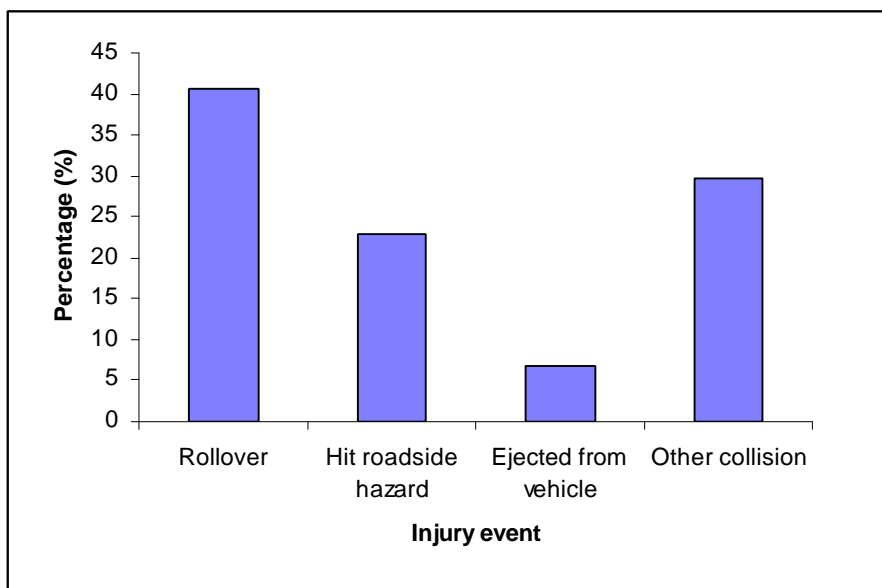


Figure 6: Description of the injury event for cases suffering their SCI as occupants of vehicles, Australia 1998/99 (percentages)

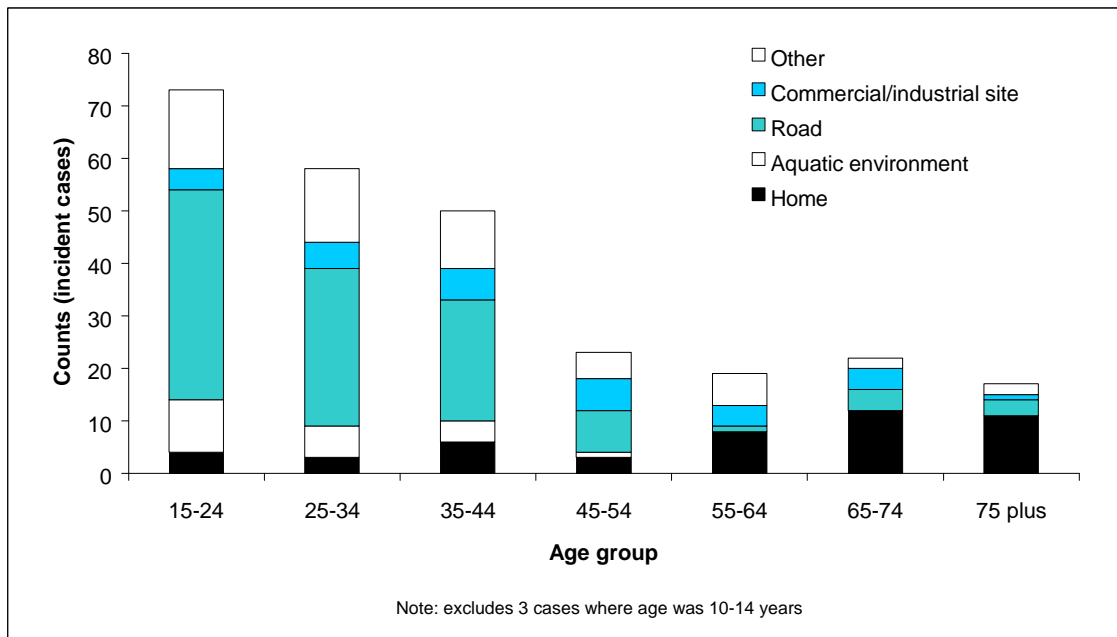


Figure 7: Incidence of SCI from traumatic causes by place of injury (major groupings) and age group, Australia 1998/99 (counts)

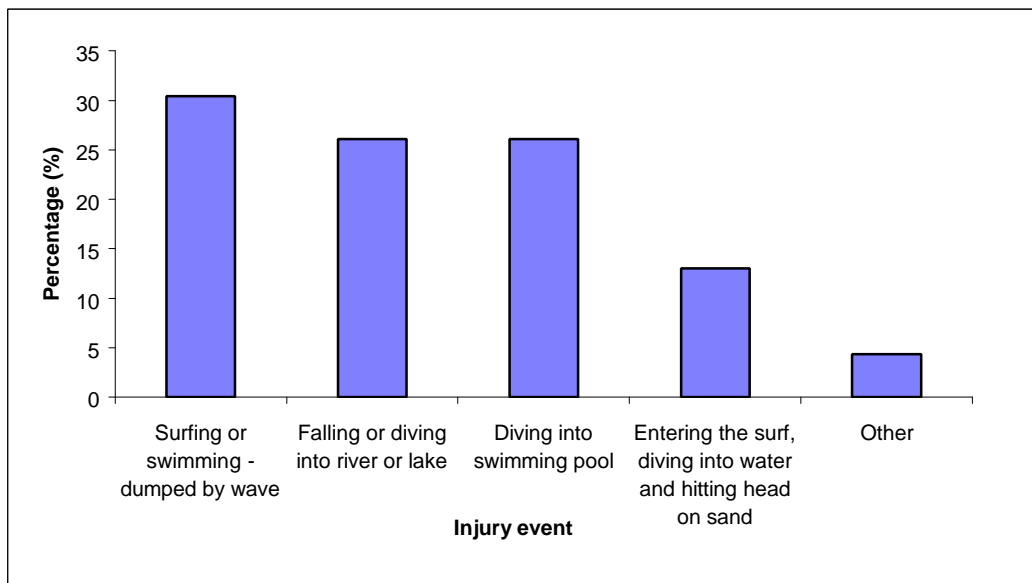


Figure 8: Description of the injury event for cases suffering their SCI in aquatic environments, Australia 1998/99 (percentages)

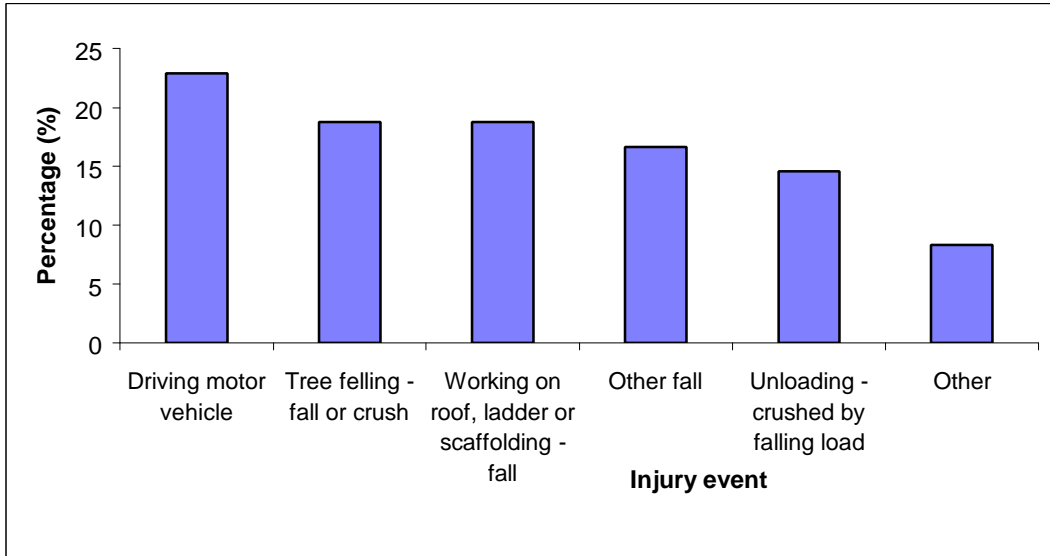


Figure 9: Description of the injury event for cases suffering their SCI while working for income, Australia 1998/99 (percentages)

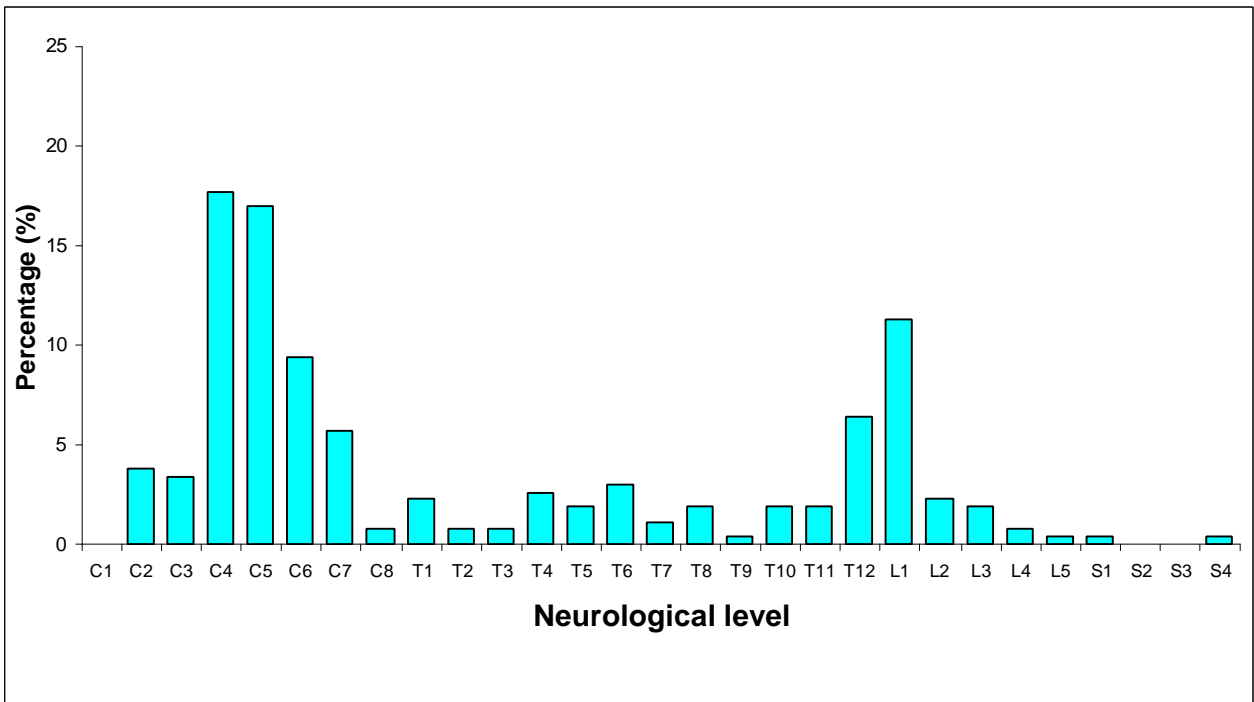


Figure 10: Incidence of SCI from traumatic causes by neurological level of injury at admission, Australia 1998/99 (percentages)

Table 1: Incidence of SCI from traumatic causes by neurological level (major grouping) and extent of injury at admission, Australia 1998/99 (counts and column percentages)

Extent of injury	Tetraplegia		Paraplegia								Total	
	Cervical		Thoracic		Lumbar		Sacral		All Paraplegia			
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Complete	51	33	40	61	8	18	0	0	48	43	99	37
Incomplete	101	66	26	39	36	82	2	100	64	57	165	62
Not specified	1	1	0	0	0	0	0	0	0	0	1	1
Total	153	100	66	100	44	100	2	100	112	100	265	100

Table 2: Incidence of SCI from traumatic causes by external cause (major groupings), and neurological level, of injury at discharge, Australia, 1998/99 (counts and column percentages)

External cause of injury	Tetraplegia		Paraplegia								Total	
	Cervical		Thoracic		Lumbar		Sacral		All Paraplegia			
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Motor vehicle occupant	52	34	11	17	10	23	1	50	22	20	74	28
Unprotected road user	14	9	20	30	4	9	1	50	25	22	39	15
Low fall (<1m)	19	12	1	2	2	5	0	0	3	3	22	8
High fall (1m +)	28	18	17	26	16	36	0	0	33	29	61	23
Struck by object	28	18	12	18	9	20	0	0	21	19	49	18
Other cause	12	8	5	8	3	7	0	0	8	7	20	8
Total	153	100	66	100	44	100	2	100	112	100	265	100

Table 3: Chart showing key characteristics of the most often quoted studies of survival from SCI

Author (publication years)	Injury period (End of follow-up)	Geographic location	Selection criteria	Cases (Deaths)	Survival parameter	Results (Group)	Relative survival ¹ (Group)
Mesard et al. (1978)	01.10.1955 to 30.09.1965 (30.06.1967)	Washington, DC, USA	Veterans with SCI treated in a Veterans Administration hospital that survived the first three months	2323 (1276)	10 year cumulative survival probability (CSP)	86% (paraplegic) 80% (tetraplegic)	88% 82%
Whiteneck et al. (1992)	01.01.1943 to 31.12.1970 (21.12.1990)	Aylesbury and Southport, England	SCI cases treated in two rehabilitation hospitals that resided in a thirteen county catchment area surrounding the hospitals. Admitted within one year of injury and survived the first year. Losses to follow-up	834 (362)	10 year CSP 20 year CSP 30 year CSP 40 year CSP	85% 71% 53% 35% <u>10 year CSP:</u> Incomplete paraplegia 96% (<30 years) 84% (30-49 years) 67% (50+ years) Complete paraplegia 91% (<30 years) 81% (30-49 years) 50% (50+ years) Incomplete tetraplegia 96% (<30 years) 70% (30-49 years) 56% (50+ years) Complete tetraplegia 86% (<30 years) 71% (30-49 years) 53% (50+ years)	7 extra deaths/1000 pop. (age 20-30 yrs.) 25 extra deaths/1000 pop. (age 60-70 yrs.)
Kraus et al. (1979)	01.1.1971 to 31.12.1971 (31.12.1976)	California, USA	SCI cases residing in Northern California that survived more than one day	619 (320)	5 to 6 year CSP	84%	94.8% ²

DeVivo et al. (1987)	01.01.1973 to 21.12.1980 (21.12.1981)	Multi-state and multi-centre, USA	SCI cases treated in seven rehabilitation hospitals. Admitted within one year of injury and survived more than one day. Losses to follow-up	5131 (459)	7 year CSP	86.7% overall Incomplete paraplegia ³ 94.8% ± 3.5% (1-24 years) 89.9% ± 5.1% (25-49 years) 65.9% ± 13.7% (50+ years) Complete paraplegia 94.7% ± 2.4% (1-24 years) 90.0% ± 3.5% (25-49 years) 72.9% ± 10.2% (50+ years) Incomplete tetraplegia 96.4% ± 1.8% (1-24 years) 88.4% ± 5.3% (25-49 years) 55.5% ± 10.6% (50+ years) Complete tetraplegia 89.2% ± 2.9% (1-24 years) 79.6% ± 5.3% (25-49 years) 22.7% ± 11.6% (50+ years)	95.9% 91.5% 75.7% 95.9% 91.6% 82.8% 97.6% 90.1% 66.1% 90.3% 80.8% 27.2%
DeVivo et al. (1992a)	01.01.1973 to 31.12.1984 (31.12.1985)	Multi-state and multi-centre, USA	SCI cases treated in thirteen rehabilitation hospitals. Admitted within one year of injury and survived more than one day. Losses to follow-up	9135 (854)	7 year CSP 12 year CSP	89.2% overall 85.1% overall Incomplete paraplegia ³ 94.5% ± 2.5% (1-24 years) 91.6% ± 2.9% (25-49 years) 72.5% ± 9.8% (50+ years) Complete paraplegia 93.5% ± 2.7% (1-24 years) 89.1% ± 2.7% (25-49 years) 60.8% ± 14.7% (50+ years) Incomplete tetraplegia 94.8% ± 2.2% (1-24 years) 89.0% ± 3.3% (25-49 years) 52.6% ± 12.9% (50+ years) Complete tetraplegia 87.1% ± 2.9% (1-24 years) 71.8% ± 5.7% (25-49 years) 18.1% ± 8.0% (50+ years)	96.5% 94.8% 96.9% 95.5% 91.9% 81.8% 96.8% 92.5% 77.6% 90.0% 74.0% 26.9%
Geisler et al.	01.12.1973 to	Ontario,	SCI cases treated in rehabilitation	1478	Extra deaths		15.2 extra deaths

(1983)	31.12.1980 (n.a.)	Canada	hospital that survived more than one year. Losses to follow-up	(194)	per 1000 person years		
Griffin et al. (1985)	01.01.1935 to 31.12.1981 (n.a.)	Minnesota, USA	All SCI cases residing in Olmsted County admitted to Mayo Clinic	154 (117 at 10 years, 138 at 20 years)	10 year and 20 year CSP for those surviving at least a year	87% (10 year) 78% (20 year)	20 year RS based on CSP estimated at 85% (age <35 years) and 71% (age 35+ years) ⁴
DeVivo et al. (1992b and 1992c)	01.01.1971 to 21.12.1986 (n.a.)	Multi-state and multi-centre, USA	SCI cases treated in six rehabilitation hospitals. Admitted within one year of injury and survived more than one day. Losses to follow-up	6563 (330)	2 year CSP ⁵	90.0% (1973-77) 90.4% (1978-80) 92.1% (1981-83) 94.1% (1984-86)	n.a.
Samsa et al. (1993)	01.01.1940 to 01.06.1987 (n.a.)	USA	Veterans with SCI that survived more than three months	5545 (n.a.)	40 year CSP	48% approx.	72% ⁶
Kiwerski et al. (1993)	01.01.1965 to 31.12.1989 (n.a.)	Konstancin, Poland	SCI cases treated in rehabilitation hospital who were admitted within two weeks of injury	3486 (311)	8 and 9 year CSP	87.4% (1965-73) 88.1% (1974-81) 91.2% (1982-89)	n.a.
McColl et al. (1997)	01.01.1945 to 31.12.1990 (31.12.1991)	Ontario, Canada	SCI cases treated at two rehabilitation hospitals covering central and southeastern Ontario. Aged 25-34 years and survived at least one year	606 (142)	10 year CSP 20 year CSP 30 year CSP 40 year CSP	92% 81% 63% 43%	n.a.
Hartkopp et al. (1997a, 1997b)	01.01.1953 to 31.12.1990 (31.12.1992)	Denmark	SCI cases treated in rehabilitation hospital covering east and southeast Denmark, Greenland and Faroe Island. Excludes patients requiring permanent respiratory support	888 (236)	10 year CSP 20 year CSP	78.7% (males, 1953-71) 86.8% (males, 1972-90) 72.1% (females, 1953-71) 86.9% (females, 1972-90) 60.6% (males) 66.7% (females)	84.0% 93.8% 74.6% 92.0% 90.6% 87.2%
Yeo et al. (1998)	01.01.1955 to 31.12.1994 (01.07.1996)	New South Wales, Australia	SCI cases treated in rehabilitation hospital covering part of Sydney. Excludes deaths within 18 months	1453 (329)	25 year CSP	80% (paraplegic) 72% (tetraplegic)	91% 81%

n.a. not available

- 1 Relative survival is survival of SCI cases relative to the general population from which the cases originated. Where indicated, these are based on CSP
- 2 Applies to those surviving at least one week
- 3 95% confidence interval shown

Acknowledgments

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The assistance of the Director's and staff of the spinal units is gratefully acknowledged, as is the assistance of Dr. Raymond Cripps of RCIS who is involved with unit liaison and quality assurance.

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".

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

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.

Data issues

Rates

Incidence rates have been calculated as cases per million of the usually resident population of Australia. ABS population data were used for this purpose. Annual rates were calculated using finalised population estimates for each year. The 1998 finalised population estimate was not available at the time that this report was prepared and the 1997 estimate was used for that year. As the Australian population increases each year by about one percent, reported rates of SCI for 1998/99 could be about one percent higher than would otherwise be the case.

All-ages rates have been adjusted to overcome the effects of differences in the proportions of people at different ages (and different injury risks) in the populations that are compared. Direct standardisation was employed, taking the Australian population in 1991 as the standard.

All (or nearly all) cases of SCI are registered, so sampling errors do not apply to these data. However, the time periods used to group the cases (ie. calendar years) are arbitrary. Use of another period (eg. July to June) would result in different rates.

Confidence intervals

Where case numbers are small, the effect of chance variation on rates can be large. Confidence intervals (95%, based on a Poisson assumption about the number of cases in a time period) have been placed around rates as a guide to the size of this variation. Chance variation alone would be expected to lead to a rate outside the interval only once out of 20 occasions. An extreme rate in a single period of enumeration should not be ignored simply because of a wide confidence interval - a time series may show such a rate to be part of a trend.

Communications

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