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Original Article

Prevalence of spinal cord injury in Australia

PJ O'Connor*,[1,2]

[1]*Kingswood, South Australia, Australia*

Study design: Cohort study, based on cases of spinal cord injury (SCI) that occurred between 1986 and 1997 ($n = 2959$).
Objectives: To estimate prevalence historically, currently and into the future.
Setting: Australia.
Methods: Prevalence was estimated on the basis of (1) historical data concerning survival and the relationship between the incidence of fatalities and SCI, (2) information on SCI incidence and survival 1986–1997, and (3) forecasts of incidence and population growth from 1997 to 2021 and consideration of survival.
Results: It was estimated that the prevalence of SCI in Australia was in the range 8096–9614 cases by 1985. By 1997, this had increased to nearly 10 000 and the prevalence rate was more than 681 per million of population. By 2021, this could increase to nearly 12 000 if age-specific SCI incidence rates continued at average values evident over the period 1986–1997 and national population projections applied. In addition, there would be more elderly SCI cases due to the ageing of the national population. The prevalent population could be reduced to less than 7000 if the incidence rate was reduced by −3% p.a.
Conclusion: The prevalence of SCI in Australia has increased and it will continue to increase unless measures are taken to control incidence. The case mix will change due to the ageing of the population, and treatment services will need to be prepared for a larger and more elderly prevalent population. It was suggested that consideration should be given to a national health and welfare goal to reduce the SCI incidence rate by −3% p.a., focusing in particular on the prevention of transport crashes and falls.
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Keywords: prevalence; spinal cord injury; forecasting; trends; incidence; survival

Introduction

Information on the prevalence of spinal cord injury (SCI) is important for the planning of services for the disabled and also for decisions about the prevention and control of SCI. Current and future estimates are required.

Blumer and Quine[1] have shown that prevalence estimates varied widely among and also within developed countries. These variations not only reflected the dynamic nature of prevalence but also the different reported incidence rates and expectations of life of the populations studied. Many of the studies reviewed by Blumer and Quine[1] were quite dated and there were relatively few studies that provided current estimates. Estimation of the growth in the prevalent population over time has been hampered by the lack of historical data on incidence and survival rates.

In order to gauge the future impact of SCI, some studies have estimated future prevalence.[2,3] However, these forecasts have used fixed estimates of incidence and survival and have not taken into account population change, particularly ageing, and trends in incidence and survival.

Prevalence is dynamic and reflects continuous changes in age-specific incidence, duration and other population parameters.[4] In consideration of this, the present study sought to: (a) assess prevalence using current incidence and survival data from the Australian Spinal Cord Injury Register (ASCIR), (b) estimate the likely incidence of SCI historically, and (c) provide forecasts based on various assumptions about changes in the incidence rate, survival and population change.

*Correspondence: PJ O'Connor, 40 Seafield Avenue, Kingwood, South Australia 5062 Australia

[2]Formerly Director of the Australian Spinal Cord Injury Register (ASCIR). Currently, an epidemiologist and risk management consultant in private practice

Table 1 Summary of survival studies reported in the literature

Reference study	*Period*	*Remaining years of life*
Yeo *et al*[10]	1955–1994	33–36 years for age at injury of 35 years
Frankel *et al*[11]	1943–1991	23–30 years for age at injury of 35 years
McColl *et al*[12]	1945–1990	38 years based on an average age at injury of 30 years
Whiteneck *et al*[13]	1943–1970	32 years based on a case series aged 15–55 years
Geisler *et al*[14]	1945–1980	32–37 years for age at injury of 30 years, and 24–28 years for an age at injury of 40 years

Methods

Prevalence was estimated on the basis of the relationship of prevalence (P) to the multiplicative product of disease incidence (I) and disease duration (D) ie $P=ID$.[5] The incidence and survival measures used were those available from the ASCIR for the period 1986–1997 referring to persons aged 15 years and over.[6–8]

As the current prevalence of SCI will reflect incidence and survival prior to 1986, these parameters were estimated historically. Incidence was estimated historically on the basis of the relationship between the number of cases of SCI and injury deaths observed over the period 1986–1997. In order to assess the external validity of the model, the expected incidence rate was cross-checked against the incidence rate of SCI 1978–1985 reported in Victoria using an incidence register that was a forerunner to the ASCIR.[9] The historical survival rate was estimated from studies reported in the literature (Table 1).

Finally, the effect of incidence forecasts, survival and population projections were considered. A number of different models were proposed, of which three are considered here. Model 1 assumed that the crude rate of SCI would decline from 1997 to 2021 in accordance with the observed trend for 1986–1997 (ie −1.13% p.a.). Model 2 assumed that age-specific rates would continue at the average values of the period 1986–1997, applied from 1997. Model 3 assumed that the crude rate would decline by −3% p.a. from 1997. This is considered as an achievable national target.

All models used population projections provided by the Australian Bureau of Statistics.[15] They also assumed no change in life expectancy to that evident in 1986–1997, providing conservative estimates of prevalence.

Results

Prevalence estimate based on ASCIR Data, 1986–1997
Over the period 1986–1997 there was on average 246.58 new incident cases of SCI each year and 2959 in total over the period. The average remaining years of life was 40.35 years at an average age at injury of 36 years.[8] On the basis of this information it was estimated that the prevalence of SCI was 9950 in 1997 and the prevalence rate was 681 per million population.

Historical estimate of prevalence
Given that the incidence of severe injury, as measured by the injury death rate, was known to be higher prior to 1986, it was expected that the incidence of SCI would also have been higher historically. When the number of cases of SCI was compared to the annual number of injury deaths 1986–1997, it was found that there were approximately 3.4 cases of SCI for every hundred injury deaths in the age range 15 years and above (range = 3.0–3.7). The result of application of this expectation to annual injury deaths from 1921 is shown in Figure 1, which also shows the actual case number for 1986–1991. There was a rough correspondence between the expected and actual case number.

Figure 2 presents the expected case number as a rate per million of population. During most of the 1950s and 1960s the estimated rate was around 30 cases per million populations, but declined steadily from the 1970s. The average rate over the period 1950–1985 was about 27 cases per million populations. Burke *et al*[9] recorded 628 cases of SCI in Victoria over a $7\frac{1}{2}$-year period mid-1978 to December 1985. It is known that there are very few paediatric cases of SCI. Therefore, in order to provide an estimate comparable with those of the present study, the rate for Victoria was calculated on the basis of persons aged 15 years and over. At the mid-point of this period (1982), the population of persons aged 15 years and over was 3,019,211.[15] It can therefore be calculated that the SCI rate in the Burke *et al.*[9] study was about 28 cases per million population. This is higher than estimated in the present study: 23 per million population

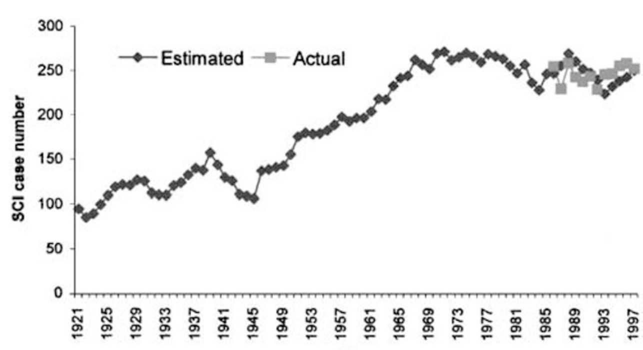

Figure 1 Estimated SCI incidence among persons aged 15 years and over, Australia 1921–1997

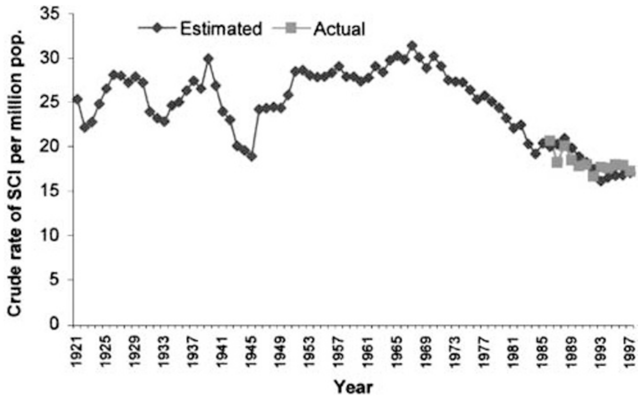

Figure 2 Estimated SCI incidence rate among persons aged 15 years and over, Australia 1921–1997

in 1982, suggesting that the incidence rate estimated on the basis of changes in the injury death rate is conservative.

From Figure 1, it appears that the estimated incidence was relatively stable from the mid-1960s with an average of about 253 cases per year (based on estimated cases 1965–1985 and actual cases 1986–1997). The estimated remaining years of life for the period prior to 1986 was estimated from studies reported in the literature. Table 1 provides information for those studies that reported results for a group of patients with age similar to the mean age based on the ASCIR survival study (ie about 36 years).

Assuming an average of 253 cases of SCI per year from the mid-1960s and average remaining years of life of 32–38 years, it was estimated that the prevalence of SCI was in the range 8096–9614 cases in 1985.

Prevalence Forecast: Model 1

If the rate of SCI reduced by 1.13% p.a. from 1997, as observed for the period 1986–1997, by the 2021 the incidence of SCI would be 259. If life expectancy were as observed in 1986–1997, the SCI prevalent population would be 10 451 by 2021 (Table 2).

Prevalence Forecast: Model 2

If age-specific incidence rates continued at average values evident over the period 1986–1997, the incident case number would be 330 in 2021. However, the case mix would change under this model toward a greater number and proportion of elderly persons; 32 cases p.a. in 1997 (13% of cases) compared with 57 cases p.a. in 2021 (17% of cases), in accordance with the ageing of the population structure. Therefore, age-specific survival rates observed over the period 1986–1997[8] were applied to the 2021 case mix. Based on this approach, the prevalent population was estimated at 11 871 in 2021 (Table 2).

Prevalence Forecast: Model 3

If the rate of SCI could be reduced by 3% p.a. from 1997 then by 2021 the incidence of SCI would be 164 cases. If life expectancy were as observed in 1986–1997, then the prevalent population would reduce to 6617 by 2021 (Table 2).

Discussion

In Australia, the SCI prevalence rate among persons aged 15 years and over was 681 per million population in 1997. Assuming that the number of paediatric cases was negligible, this equates to a rate of 534 per million population among persons of all ages. This is lower than reported in the USA but higher than some European estimates. Using the estimate of the National Center for Injury Prevention and Control[16] of 200 000 in 2001, the prevalence rate can be calculated to be about 700 per million populations in the USA. Estimates in the range of 250–520 per million population have been reported in Europe[1,17–20] although some of these estimates are rather dated and do not reflect recent increases in life expectancy.

Considering the historical estimates of prevalence, it seems likely that by 1985 the prevalence of SCI in Australia was in the range 8096–9614. This is higher than estimated by Walsh.[3] His estimate appears to have been based on a survival estimate of only 20 years of remaining life, which is considerably lower than other studies have suggested (Table 1).

With increasing survival and only little change in the incident case number evident from 1986, the prevalent population in Australia increased to nearly 10 000 by 1997. This is comparable with the estimate made by Yeo *et al.*[10]

Table 2 Summary statistics for forecasting models[a]

	Model 1	*Model 2*	*Model 3*
Estimated incidence in the year 2021	259	330	164
Estimate of remaining years of life	40.35	[b]	40.35
Estimated prevalence	10 451	11 871	6617

[a]For comparison, the estimated prevalence for 1997 was 9950
[b]Based on average age-specific values, 1986–1997

Further increase in the prevalent population is likely in Australia. The prevalent population is also reported to be increasing in other countries.[1,2,21,22] As a consequence, costs are projected to increase.[3,23]

There are a number of possible future scenarios, which can be partly determined by decisions made now about the prevention and control of the SCI incidence rate and also considering population projections and life expectancy. Even if the decreasing trend in the crude rate of SCI observed over the period 1986–1997 (ie −1.13% p.a.) continued into the future, prevalence would increase slightly: more-so if life expectancy increased further. Under a 'steady-state' assumption, with the age-specific incidence rates continuing at the average values observed over the period 1986–1997, prevalence would increase to 11 871. This would be even greater if it were not for the ageing of the population, which would increase the proportion of elderly cases who have poorer survival experience. The change in the case-mix also needs to be considered. Owing to the ageing of the general population, it is expected that the number and proportion of elderly SCI cases will increase. This has already been noted elsewhere.[24,25] As the elderly are more likely to suffer tetraplegia, and their care needs are different from the younger tetraplegia patient, the demands on treatment centers will increase.

It is against the backdrop of these expected increases that the need to control prevalence should be considered. The drivers of prevalence are incidence, duration and population parameters.[4] There is nothing that public health advocates and clinicians can do to alter population growth and nothing they should do to reduce life expectancy. However, they can and should focus on reducing incidence, particularly if medical and other advances continue to increase life expectancy.

In order to determine a realistic target for reducing the incidence of SCI, consideration needs to be given to the evidence of what has been achieved in the past. Injury mortality rates have declined substantially in Australia over the last 20 years.[26] The largest contributor to this decline was a substantial reduction in transport-related deaths. There has been a substantial investment from the early 1970s in effective public health measures, such as random breath testing, seat belt and helmet laws, and graduated licensing, to control transport-related injury in Australia.[27–31] The success of these measures is shown in a −6% p.a. decline in the transport-related death rate and a −4% decline in the transport-related SCI rate, over the period 1986–1997. On the basis of the evidence of what can be achieved in injury prevention, reducing the incidence rate of SCI by −3% p.a. is realistic. If this were to be achieved, the prevalence of SCI in Australia would reduce toward 6617 even considering population growth. Increased life expectancy would increase prevalence beyond this estimate, although the impact would be dampened by the expected increase in the proportion of elderly people in the SCI population.

More consideration needs to be given to the means to achieve a sustained reduction in the incidence of SCI. Internationally, it would be worthwhile to review the successful interventions so that they can be promoted and adopted elsewhere, where relevant. The principal focus should be transport crashes and falls, which are the main causes of SCI.

While a great deal has been achieved in terms of a reduced incidence of transport-related SCI in Australia, there is more that can be done. A recent study[30] showed that in single vehicle car crashes in the country, the likelihood of SCI was especially high in nonsedan-type cars, such as four-wheel drive vehicles, involved in rollover crashes; 10 times higher than sedans. Concern was expressed over the increasing proportion of four-wheel drive passenger vehicles (sport utility vehicles: SUV) in the car fleet in Australia, the USA and elsewhere, as they are more prone to rollover.[32] In order to deal with the problem, the rollover potential of all new cars should be assessed and reduced. This has been recently initiated in the USA (http://www.nhtsa.dot.gov/cars/testing/ncap/info.html) but has not been introduced in Australia (http://www.aaa.asn.au/pages/ancap.htm) and is not universal elsewhere. Associations such as the International Spinal Cord Society should put pressure on vehicle standards authorities in each country to require tests of rollover resistance as a component of new car assessment programmes, to improve vehicle design.

A reported[33] escalation in fall-related SCI particularly in elderly males, and increases in fall-related incomplete tetraplegia and complete paraplegia in Australia is a concern. This is not unique to Australia as the shown by a recent Finnish study[24] and a study in the United States.[25] It is not clear why the increase has occurred and it warrants further investigation. The discussion by Kannus *et al*,[24] Alaranta *et al*[34] and Liang *et al*[35] suggests that osteoporosis, ankylosing spondylitis and spondylosis could be contributing factors to the epidemic of elderly male fall-related SCIs. It is also possible that healthy ageing and the 'handy-man movement' carries unforeseen incremental risks by encouraging the elderly to continue to engage in home maintenance activities involving heights, such as cleaning and painting gutters, repairing rooves and picking fruit. Alaranta *et al*[34] recommends that male patients with advanced ankylosing spondylitis should embrace fall prevention strategies by fitting night-lights and handrails and avoiding slippery surfaces and loose carpets, and should be encouraged to avoid excessive use of alcohol.

Conclusions

The prevalence of SCI in Australia has increased and it will continue to increase unless measures are taken to control incidence. The case mix will change due to the ageing of the population, and treatment services will need to be prepared for a larger and more elderly prevalent population. It was suggested that consideration should be given to a national health and welfare goal to reduce the SCI incidence rate by −3% p.a., focusing in particular on the prevention of transport crashes and falls.

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