

Spinal cord injury in Manitoba: a provincial epidemiological study

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Objective: To define the epidemiological trends and identify populations at risk of traumatic and non-traumatic spinal cord injury (NTSCI) for the province of Manitoba, Canada.

Methods: We reviewed records retrospectively for subjects in three cohorts (1981–1985, 1998–2002, and 2003–2007). A total of 553 individuals with spinal cord injury (SCI) were studied for variables such as age, level of injury, severity of injury, First Nations (FN) status, and etiology of injury.

Results: Incidence of overall SCI has increased from 22.0 to 46.5 per million ($P < 0.001$). Incidence of NTSCI increased from 3.12 per million to 16.7 per million ($P < 0.001$). Incidence of traumatic spinal cord injury (TSCI) has increased from the 17.1 per million to 25.6 per million ($P < 0.001$). There was a significant increase in the mean age at injury from 30.23 to 45.768 years of age ($P < 0.0001$). Female and NTSCI have a higher mean and median age at injury. There was a significant ($P = 0.0008$) increase in the proportion of females with a most recent male/female ratio of 3.4:1. A temporal increase in incomplete injuries was observed ($P < 0.0001$). Incomplete and thoracic level injuries are more common with NTSCI.

Conclusion: The results demonstrate that there are significant differences between NTSCI and TSCI in Manitoba, and that Manitoba trends in SCI are in keeping with those seen on a national and an international level. There is a high risk of SCI in Manitoba FN, for which preventive strategies need to be put in place, and higher resource structure geared towards. Additionally, the trend of older age at injury has significant implications for structuring acute care and rehabilitation programs for these individuals, enhancing the need for treating older and more medically complicated individuals with SCI.

Keywords: Spinal cord injury, Traumatic, Non-traumatic, Retrospective, Epidemiology, Canada

Introduction

Spinal cord injuries (SCI) have diverse non-traumatic and traumatic etiologies with varying degrees of resultant neurological damage. Regardless of the cause and the severity, SCI often results in devastating effects on the injured persons' medical, functional, psychosocial, and financial well-being.^{1–3} Epidemiological SCI studies conducted in Canada and internationally to date have focused on traumatic SCI (TSCI), leaving-out non-traumatic causes such as spinal stenosis or neoplasm.^{4–6} Manitoba has a unique geography and population compared to many of the epidemiologic studies available, in that there are large, very sparsely populated areas, especially in the northern 3/4 of the province, with a large first nations (FN) population including those of aboriginal, Métis, and Inuit descent. More information is needed on both the non-traumatic SCI (NTSCI) and TSCI in this unique population and

geography in order to capitalize the distribution of health care resources and to direct potential preventative strategies. This study aims to define the trends and elucidate the populations at risk in non-traumatic and TSCI in Manitoba and compare these data to recent trends seen nationally and internationally.^{4–16} In keeping with national and international demographic trends as well as clinical experience, we anticipate a male majority, SCI most commonly caused by motor vehicle accident (MVC), increasing number of fall-related SCI, increasing mean age at injury, and a higher proportion of cervical SCI.^{4–16}

Methods

After approval from the ethics committee regarding our study, the data for this study were gleaned from two provincial sources, the Winnipeg Rehabilitation Hospital at the Health Sciences Center and the database at the Manitoba branch of the Canadian Paraplegic Association. Inclusion criteria included survival to hospital admission with traumatic or NTSCI, or outpatient

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referral to an SCI rehabilitation specialist. NTSCI exclusion criteria included congenital causes of paralysis such as spina bifida or cerebral palsy as well as acquired paralysis from multiple sclerosis or Guillain-Barré syndrome. Variables including age at injury, etiology of injury, gender, and level and severity of injury were recorded.

Analysis for mean age was done using general linear models, for gender using the frequency and contingency tables (FREQ) procedure (chi-square) and for incidence using the Generalized Linear Modeling (GENMOD) procedure (Poisson distribution). Using the Canadian Census Population results, as well as the Manitoba Health Population Reports, the total mean incidence rates for SCI in Manitoba were calculated.^{17,18}

Results

Using the inclusion criteria, 553 subjects (M/F = 419/134) with SCI over three cohorts (1981–1985, 1998–2002, and 2003–2007) were collected.

Each successive cohort showed an increase in annual incidence of total SCI, rising from 20.2 to 33.5 to 42.6 per million (Table 1). The male incidence rate increased over each successive cohort from 17.4 to 22.8 to 32.9 per million compared to the female incidence rate, which increased from 2.7 to 11.1 and finally 9.7 per million.

Table 1 Variables of spinal cord injury in Manitoba over three cohorts

	1981–1985	1998–2002	2003–2007
Incidence (per 1 000 000 population)			
Non-traumatic	3.1	14.1	16.7
Traumatic	17.1	19.5	25.6
FN	48.9	55.3	78.9
Non-FN	17.3	26.6	32.2
Total SCI incidence	20.2	33.5	42.6
Mean/median age			
Non-traumatic	36.3/34.0	53.1/54.0	54.7/58.0
Traumatic	29.0/25.0	35.3/31.5	39.8/38.0
Female	32.1/28.0	46.6/46.0	48.5/51.0
Male	30.0/25.5	41.4/39.5	44.8/46.0
Total	30.2/26.0	43.1/41.0	45.7/47.0
Level of injury (total number per 5-year cohort)			
Non-traumatic			
Cervical	8	21	29
Thoracic	8	43	49
Lumbar	3	16	18
Sacral	0	1	2
Traumatic			
Cervical	42	50	78
Thoracic	30	37	53
Lumbar	19	24	19
Sacral	0	0	2
Severity of injury (total number per 5-year cohort)			
Non-traumatic			
Incomplete	10	66	87
Complete	7	15	11
Traumatic			
Incomplete	37	68	79
Complete	56	44	73

The proportion of females increases significantly from the first cohort ($P = 0.0008$, χ^2 test). The first cohort (1981–1985) showed a 6.3:1 male/female ratio in incidence. This ratio changed to approximately 2.1:1 in the next cohort and 3.4:1 in the final cohort. In the Manitoba FN population, incidence rates per million increased from 48.9 to 55.3 to 78.9 per million. Incidence of SCI in all other Manitobans changed over the three cohorts from 17.3 to 26.6 to 32.2 per million (Table 1).

Non-traumatic incidence was calculated (Table 1). The first cohort was found to be significantly lower than the subsequent cohorts ($P < 0.0001$). For each 5-year cohort in our study, we found that the percentage of NTSCI changed from 15.5% to 42.0 and 39.2%, respectively.

Incidence of TSCI was calculated showing a change from 17.1 to 19.5 to 25.6 per million (Table 1). The change in incidence was found to be significant ($P = 0.0015$) from cohort 1 to cohort 3 but not from cohort 1 to cohort 2 ($P = 0.3427$).

Mean and median age at injury were calculated (Table 1). The difference between cohorts 1 and 2 and cohorts 1 and 3 was shown to be significant with a $P < 0.0001$. There was a decrease in males <30 years of age over all three cohorts from 66/95 (69.47%) to 44/131 (33.6%) to 47/193 (24.4%). There was an increase in the proportion of SCI in those over age 65 from cohort 1 to cohorts 2 and 3 ($P = 0.0004$, χ^2 test).

NTSCI was most common in those over age 40 years and showed a higher median and mean age of injury in all three cohorts than TSCI (Table 1). The highest proportion of NTSCI occurred in those in the age group 61–70 years of age, whereas the highest proportion of TSCI was found in those aged 16–24. Anyone over age 50 years was less likely to have TSCI than those aged 16–24 years ($P < 0.001$).

The majority of NTSCI were in males but there were an increasing number of females with NTSCI from cohort 1 to cohorts 2 and 3 (7/16 to 36/81 and 28/93). Similarly, Manitoba’s TSCI male/female ratio changed from 12:1 to 3.3:1 to 4.4:1 due to an increasing number of females sustaining SCI.

Vehicular collisions accounted for 50.5% of all TSCI over all cohorts and were also the number one cause of all SCI for ages 15–29 in all cohorts. Falls accounted for 24% of TSCI for all ages. In those over age 60, falls accounted for 62.2% of TSCI, whereas in those under age 60 years, falls accounted for only 19.9% of TSCI. NTSCI were most often incomplete in severity and at the thoracic level (Table 1). TSCI were more commonly cervical level with a shift from complete severity to more

even distribution in the last cohort (Table 1). The top causes of NTSCI were cancer and spondylopathies (Table 2).

Discussion

Internationally, SCI has an annual incidence of approximately 15–40 cases per million, with recent estimates in Canada being approximately 35 per million.^{19–21} The most recent Manitoba incidence for total SCI is slightly higher than these national and international estimates and has actually shown a significant increase ($P < 0.0001$) from 20.2 (1981–1985) to 42.6 per million (2003–2007). Although part of the overall increase in SCI incidence in Manitoba can be attributed to the significant increase in TSCI, the predominant cause is the increase in NTSCI.

A recent international study found that 60% of total SCI admitted were NTSCI, with other estimates ranging from 25.0 to 50.0%.^{22–25} For each cohort in our study, we found that the percentage of NTSCI changed from 15.5% to 42.0% to 39.2% of total SCI, respectively. Using GENMOD, it was determined that

the change over time for NTSCI incidence is significantly greater (<0.0001) than the change over time for TSCI. Part of the surge in NTSCI may be attributed to an increase in the number of referrals to SCI specialists. Until the establishment of the only spinal cord unit in Manitoba in 1984, SCI were assessed among the community hospitals and thus would not be included in our data. Another possible explanation for the increase in NTSCI may be the increase in life expectancy leading to an increase in the elderly segment of our population.²⁶ Indeed, NTSCI showed a higher median and mean age of injury in all three cohorts compared to TSCI. These results vary from those found in the literature with mean ages at NTSCI of 30.6 and 61.2 being reported elsewhere.^{23,24} Findings associated with a greater age at injury are of concern as it is documented that older subjects with SCI tend to have a longer hospital admission, higher rates of complications, and increased mortality.^{4,14,15,27–29}

The difference in age between TSCI and NTSCI may be linked to the etiology of NTSCI, which include conditions that are more likely to be found in older individuals, such as cancer or spinal stenosis. For instance, in the last two cohorts, spondylomyelopathy accounted for 21.0 and 25.0% of NTSCI, whereas tumor/cancer accounted for 30.0 and 21.0% (Table 2). Tumors have been found to cause from 20.6 to 26.6% of NTSCI in other studies.^{23,24,30} The etiology may also explain the predominance of incomplete SCI among NTSCI, as the main etiological causes (spinal stenosis, tumor) are typically more insidious in onset in contrast to the characteristic acute onset of TSCI associated with such things as MVC and falls.

In keeping with trends found elsewhere, we found that there was a high proportion of fall-related SCI.^{9,15,16} Findings of fall-related TSCI range from 16.5 to 20.0%, close to our finding of 24.0%.^{4,19,21,28} Falls are an important cause of SCI in the elderly segment of the population. Pickett *et al.*⁵ found that in those aged 65 and older, 63.0% of TSCI were from falls. Similarly, we found that falls accounted for 57.7% of TSCI in those 65 years of age and older. While falls among seniors is being addressed in Manitoba by a special preventative program, falls in the younger population are currently not being addressed, possibly due to different causative factors.³¹

Motor vehicular collisions remained the foremost cause of TSCI in keeping with studies that found MVC accounts for approximately 35.0–45.6% of all TSCI.^{5,6,13} Although the relative proportion of TSCI from car MVC decreased with each cohort (47.3% to 39.3% to 34.9%), the numbers of SCI from MVC each

Table 2 Etiology of spinal cord injury over three cohorts (% of cohort totals)

	1981–1985 (%)	1998–2002 (%)	2003–2007 (%)
Traumatic			
Airplane	0.0	0.0	0.4
Car	40.0	22.8	21.2
Cycling	0.0	0.0	0.4
Diving	11.8	1.0	2.4
Equestrian	0.9	0.0	0.0
Falls	14.5	16.1	16.4
Farming accident	0.0	3.1	1.2
Motorcycle	2.7	0.5	2.0
Off-road vehicle	1.8	7.8	5.6
Other	3.6	0.0	1.2
Sports other	0.9	1.0	2.4
Suicide attempt	0.0	1.0	0.4
Work related	3.6	2.6	4.0
Violence	4.5	2.1	3.2
Non-traumatic			
Abscess	0.0	2.6	2.4
Aneurysm repair/ arterial graft	0.0	2.6	2.0
Cancer/tumor	2.7	11.4	8.4
Disc herniation	0.0	4.1	4.0
Malformation (AVM, Chiari)	0.0	1.6	0.0
Osteomyelitis/discitis	0.0	2.1	3.6
Spinal cord infarct	0.0	2.6	0.4
Spondylomyelopathy	0.0	8.8	9.6
Transverse myelitis	0.9	2.1	3.6
Tuberculosis of spine	0.0	0.0	0.8
Viral	0.0	0.0	1.2
Other	1.8	1.6	2.4
Unknown	10.0	2.6	0.8
Total number	110	193	250

year remained consistent (Table 1). What is remarkable is the increase in females with MVC-related SCI (from 9.1% (4/44) to 38.6% (17/44) and 35.8% (19/53)). This increase partially explains why Manitoba's TSCI male/female ratio changed from 12:1 to 3.3:1 to 4.4:1.

With this noted increase in NTSCI incidence, it is important to acknowledge the differences that exist between TSCI and NTSCI outcomes. For instance, it has been found that subjects with NTSCI have shorter rehabilitation stay and lower overall costs in comparison with subjects with TSCI.^{24,32} Although one study looking at NTSCI showed that 63.0% had at least one complication, the general conclusion was that overall NTSCI subjects still have a lower prevalence of complications than TSCI.³⁰ Catz *et al.* concluded that although prognosis for neurological recovery is linked mostly to SCI severity, it is typically better in NTSCI.³³ Level of injury is also an important factor in recovery as the higher the injury the greater the loss of function, the greater the duration and difficulty of rehabilitation, and the greater the direct/indirect costs.³⁴⁻³⁶ Our data support differences in level of injury, with cervical level injuries being more common in TSCI and thoracic level injuries more common in NTSCI. Causes of NTSCI such as spinal cord ischemia and metastases to vertebrae are more common in thoracolumbar level than in cervical level, thus the preponderance of lower injuries found here is not unexpected.

Finally, of concern are the higher incidence rates of SCI among the FN population of Manitoba. This is in keeping with findings on injury hospitalization in Manitoba that found that FN Manitobans have been found to have an injury hospitalization rate that was over three times that of other Manitobans. FN individuals may be at a higher risk for injury due to such factors as lower family income, higher rates of violence, unsafe housing and workplaces, substance abuse, and geographic isolation.¹⁹ Injury among FN in Manitoba is currently being addressed by the implementation of the 'Manitoba Aboriginal Injury Prevention Strategy', which is targeting such things as vehicle and water safety.²⁰

Conclusions

The strengths of this study include the use of three cohort groups and the elucidation of both traumatic and non-traumatic population characteristics in Manitoba. One limitation may be that not all SCI patients were identified as it is possible that subjects with mild NTSCI underwent evaluation and treatment at one of the smaller community hospitals, thus missing inclusion in this study. It is also possible that

patients with advanced concomitant disease were not referred for assessment as well. Neurological deficits were not classified by the World Health Organizations International Classification of Disease codes or by the American Spinal Injury Association classification scale in this study, because these data were missing in a portion of the charts under review. This may decrease the extent to which comparisons can be made to this study by future studies.

The evidence in the literature is that Canadian SCI studies have focused on TSCI, leaving a dearth of information regarding SCI of non-traumatic origin. This creates a difficulty in making meaningful comparisons with other study populations. Differences may also exist in the classification of injury.

There have been no studies established previously on SCI trends in Manitoba. This retrospective study shows trends similar to those seen nationally and internationally among NTSCI of increasing incidence, a male majority, an increase in the mean and median age at injury, and thoracic level injury, whereas among TSCI the trends are increasing incidence, a male majority, an increase in mean and median age at injury, and more cervical level of injury with TSCI. However, this study is unique in that it addresses a large, sparsely populated geography, with a large proportion of SCI seen in FN population. Although prognosis for neurological recovery may typically be better in NTSCI than TSCI,^{23,33} NTSCI still has the potential to leave individuals significantly disabled. This study demonstrates that NTSCI deserve more attention as they make up a considerable portion of SCI in Manitoba. Whereas TSCI have more homogeneous etiology and are more often preventable (MVC, falls), NTSCI has more heterogeneity and leaves little means to reduce incidence although it is recognized that enhanced recognition is helpful in the early stages.

The results of this paper indicate that discussion needs to be initiated in Manitoba about increasing current prevention strategies and possibly introducing new prevention strategies to reduce TSCI as well as early recognition and optimal rehabilitation for NTSCI. Additionally, this study indicates that FN individuals are at high risk of SCI, with a significant increased proportion of SCI in the province occurring in this population. Thus preventive strategies need to be implemented as well as increased resources to deliver services to this population of people living with SCI.

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