

## ORIGINAL ARTICLE

# Epidemiology of traumatic spinal cord injury in Tianjin, China

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**Study design:** A retrospective epidemiological study.

**Objectives:** To provide recent epidemiological characteristics of traumatic spinal cord injuries (TSCIs) in adults living in Tianjin.

**Setting:** Tianjin, China.

**Methods:** This study included all TSCI patients aged 15 years or older who were admitted to tertiary hospitals in Tianjin from 2004 to 2008. Epidemiological characteristics, such as age, sex, date of admission, causes of injury, level of injury, America Spinal Injury Association impairment scale and date of discharge were included.

**Results:** A total of 869 patients were included, with an estimated annual incidence was 23.7 per million populations. The male/female ratio was 5.63:1. Mean age of TSCI was  $46.0 \pm 14.2$  years (men  $45.8 \pm 14.2$  years, women  $47.5 \pm 14.5$  years), with a range of 16–90 years. Falls were regarded as the leading causes of injury, followed by motor vehicle collisions. The lesion level was cervical in 71.5%, thoracic in 13.3% and lumbar/sacral in 15.1%. The frequency of tetraplegia (71.5%) was higher than paraplegia (28.5%), and roughly four-fifth of tetraplegia cases were incomplete injury.

**Conclusion:** To our knowledge, national or local epidemiological study of spinal cord injury (SCI) has not been carried out previously in China. The number of SCI patients in this country is large and would increase gradually. Similar to other developing countries, falls were the main causes of TSCI. Low falls were more common in those over 60 years old. As the ageing society coming, the number of low falls-induced TSCI would increase gradually, which poses a challenge to the society health system.

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**Keywords:** spinal cord injury; China; epidemiology; incidence

## Introduction

Spinal cord injury (SCI) is a serious condition that has an impact on quality of life, life expectancy and economic burden. There are no effective restorative therapies for SCI as yet, so prevention is the best medicine at present. Epidemiological research of SCI is very important because characteristics of a specified region described in epidemiology can provide the basis for appropriate preventive measures in order to reduce the incidence of SCI.<sup>1</sup>

Internationally, incidence rates for SCI range from 10.4 to 83 cases per million of population,<sup>1</sup> with significant differences between different countries or regions. Burke *et al.*<sup>2</sup> estimated an adjusted average incidence rate of SCI was 27.1 cases per million between 1993 and 1998 in the

northwestern Kentucky and southern Indiana regions in the United States. In Australia, O'Connor<sup>3</sup> showed the age-standardized SCI incidence rate for 14.5 per million persons in 1998/1999. Among European countries, the incidence rates were lower relatively—namely, 13.8 for Finland (1976–2005),<sup>4</sup> 13.1 for Ireland (2000),<sup>5</sup> 12.7 for Turkey (1992)<sup>6</sup> and 19.4 for France (2000),<sup>7</sup> respectively. In developing countries, systematic epidemiological studies were relatively less. Otom *et al.*<sup>8</sup> reported that the incidence rates for traumatic spinal cord injury (TSCI) of 18 per million populations in Jordan, from January 1988 to December 1993. In Russia,<sup>9</sup> this rate was 29.7 per million per year between 1989 and 1994.

China is one of the largest countries in the world and has a large population having enormous SCI patients. However, as far as we know, well-designed studies that provide evaluated epidemiological characteristics of SCI in China populations are scarce. Tianjin is the third largest city in China with a total population of about 11 760 000 (2008). Our aim was to describe epidemiology of TSCI in Tianjin over a 5-year period.

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## Patients and methods

### Study population

The present study included all inhabitants aged 15 years or older living in Tianjin from 1 January, 2004 to 31 December, 2008. The total area of Tianjin is 11 917.3 km<sup>2</sup>. The total population in this city was 10 236 700 in 2004 and 11 760 000 in 2008, including 77.23% of the urban population and 22.77% rural population. The population aged 15 years or older was about 9 158 326 in 2006.

### Definition of TSCI

TSCI 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.<sup>10</sup>

### Case identification

The medical records of all patients with a diagnostic code (ICD-10), suggesting TSCI at discharge from any of the 15 tertiary hospitals, able to handle acute TSCI in Tianjin, were reviewed. Fatally injured persons and emergency room patients who were never hospitalized were excluded from this study.

### Statistical analysis

Data recorded from the medical records of all patients discharged from these hospitals, including age, sex, date of admission, causes of injury, level of injury (cervical, thoracic, lumbar or other), America Spinal Injury Association impairment scale, date of discharge and so on. The causes of TSCI were divided into motor vehicle collisions (MVCs), falls, including low falls (on the same level, or from a height of less than 1 m) and high falls (from a height of 1 m or more), struck by object, sport-related injuries, assault, work accident and other causes (that is, complications of traditional Chinese medicine and so on). The neurological deficits were classified according to the ASIA classification. This data was collected in a Microsoft Excel spreadsheet and statistical analysis was performed by SPSS version 11 (supplied by Professor Shiqing Feng, Department of Orthopaedics, Tianjin Medical University General Hospital, Tianjin, PR China).

The average incidence rates of TSCI for this time period, which were calculated based on population estimates from Tianjin Bureau of Statistics for 2006, the middle time point of the study. Children under 15 years of age were also excluded from this study.

## Results

### Incidence

In persons aged 15 and older, the numbers of TSCI in each year between 2004 and 2008 were 139, 151, 178, 200 and 201. The population increased by 15.0% in 5 years, whereas patients with TSCI increased by 44.6%. On the basis of the population data acquired from Tianjin Bureau of Statistics, it was estimated that an average incidence rate was 23.7 cases per million per year for residents in Tianjin for these 5 years.

### Gender and age

Gender and age distributions are shown in Table 1. On an average, 84.9% of the patients were male and 15.1% were female. The male/female ratio was 5.63:1. Mean age of TSCI was 46.0 ± 14.2 years (men 45.8 ± 14.2 years, women 47.5 ± 14.5 years), with a range of 16–90 years. The age distribution had a peak at 46- to 60-year group, accounting for 39.4%. As far as the incidence by age groups was concerned, the most incidence age group was from 46- to 60 years, 37.3 cases per million per year, followed by 61- to 75-years group.

### Cause of injury

Acquired from the results, 'low falls' and 'high falls' were the leading causes of injury, accounting for 56.9% of all TSCIs. In low-falls group, such as slips or trips, the incidence rate of TSCI steadily increased with age (7.5% for age group 16–30 years to 80.0% for age group older than 75 years). In high-falls group, the incidence rate tended to decrease with age (except age group 75 + years) (Figure 1). MVCs were the second most common cause of TSCI, accounting for 34.1% on average and were rather stable over the 5 years. Other causes included that 6.3% of being struck by an object, 1.4% of assault, 0.8% of work accident and 0.2% of sport-related injury. In addition, two patients sustained injuries during treatment of traditional Chinese medicine.

### Neurological level and severity of injury

The neurological level of TSCI in this study is presented in Figure 2. Over the past 5 years, cervical spine injuries have accounted for between 69.5 and 73.6% of all TSCIs. The most common cervical spine injuries involved C4 and C5 segments, accounting for 77.9% of cervical TSCI cases. Thoraco-lumbar junction (T11-L2) was the second common neurological level of injury, which accounted for 19.4% of all cases.

The severity of TSCI was measured by combining the neurological level and extent of injury into: complete tetraplegia, incomplete tetraplegia, complete paraplegia and incomplete paraplegia. A total of 496 patients (57.1%) presented with incomplete tetraplegia, followed by incomplete paraplegia (17.7%), complete tetraplegia (14.5%) and complete paraplegia (10.7%). Table 2 shows the number of TSCI according to the level and completeness of SCI, by cause of injury in Tianjin, China from 2004 to 2008.

### In-hospital mortality

A total of 12 patients (1.4% of admissions) died during hospitalization, all of which had cervical TSCI. Among the 12 patients, 5 (41.7%) were 60 or older, 10 (83.3%) were men, 7 (58.3%) were injured after a motor vehicle collision and 11 (91.7%) died because of respiratory failure.

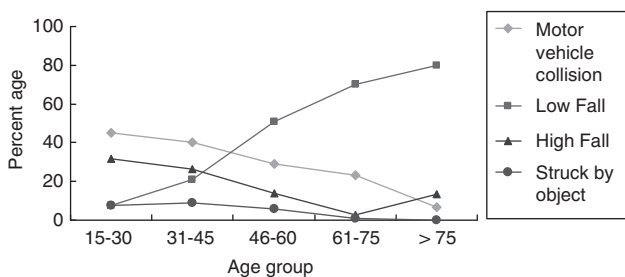
## Discussion

Nowadays most epidemiology researches of SCI are from developed countries, such as Australia, Europe and Northern America. But such information from developing countries,

**Table 1** Characteristics of traumatic SCI adults in adults living in Tianjin, China from 2004 to 2008

	2004	2005	2006	2007	2008	Total
Number of cases	139	151	178	200	201	869
Age (mean, s.d.)	42.9, 13.2	45.0, 14.3	45.8, 14.2	48.0, 14.7	47.2, 14.0	46.0, 14.2
16–30	25 (18.0%)	27 (17.9%)	27 (15.2%)	26 (13.0%)	28 (13.9%)	133 (15.3%)
31–45	51 (36.7%)	50 (33.1%)	60 (33.7%)	62 (31.0%)	52 (25.9%)	275 (31.6%)
46–60	53 (38.1%)	55 (36.4%)	66 (37.1%)	76 (38.0%)	92 (45.8%)	342 (39.4%)
61–75	8 (5.8%)	18 (11.9%)	21 (11.8%)	30 (15.0%)	27 (13.4%)	104 (12.0%)
>75	2 (1.4%)	1 (0.7%)	4 (2.2%)	6 (3.0%)	2 (1.0%)	15 (1.7%)
Gender						
Male	119 (85.6%)	139 (92.1%)	153 (86.0%)	158 (79.0%)	169 (84.1%)	738 (84.9%)
Female	20 (14.4%)	12 (7.9%)	25 (14.0%)	42 (21.0%)	32 (15.9%)	131 (15.1%)
Causes of injury						
MVC	52 (37.4%)	54 (35.8%)	56 (31.5%)	73 (36.5%)	61 (30.3%)	296 (34.1%)
Low fall	50 (36.0%)	59 (39.1%)	68 (38.2%)	77 (38.5%)	73 (36.3%)	327 (37.6%)
High fall	20 (14.4%)	30 (19.9%)	34 (19.1%)	33 (16.5%)	51 (25.4%)	168 (19.3%)
Struck by object	14 (10.1%)	5 (3.3%)	13 (7.3%)	13 (6.5%)	10 (5.0%)	55 (6.3%)
Sport-related	1 (0.7%)	0	1 (0.6%)	0	0	2 (0.2%)
Assault	1 (0.7%)	1 (0.7%)	3 (1.7%)	3 (1.5%)	4 (2.0%)	12 (1.4%)
Work accident	0	2 (1.3%)	3 (1.7%)	1 (0.5%)	1 (0.5%)	7 (0.8%)
Other	1 (0.7%)	0	0	0	1 (0.5%)	2 (0.2%)
Level of injury						
Cervical	98 (70.5%)	105 (69.5%)	126 (70.8%)	144 (72.0%)	148 (73.6%)	621 (71.5%)
Thoracic	19 (13.7%)	19 (12.6%)	24 (13.5%)	28 (14.0%)	26 (12.9%)	116 (13.3%)
Lumbar	21 (15.1%)	27 (17.9%)	28 (15.7%)	28 (14.0%)	27 (13.4%)	131 (15.1%)
Sacral	1 (0.7%)	0	0	0	0	1 (0.1%)
ASIA impairment scale						
A	45 (32.4%)	43 (28.5%)	41 (23.0%)	44 (22.0%)	46 (22.9%)	219 (25.2%)
B	26 (18.7%)	28 (18.5%)	30 (16.9%)	36 (18.0%)	38 (18.9%)	158 (18.2%)
C	19 (13.7%)	25 (16.6%)	30 (16.9%)	30 (15.0%)	24 (11.9%)	128 (14.7%)
D	49 (35.3%)	55 (36.4%)	77 (43.3%)	90 (45.0%)	93 (46.3%)	364 (41.9%)

Abbreviations: ASIA, America Spinal Injury Association; MVC, motor vehicle collision; SCI, spinal cord injury; TSCI, traumatic spinal cord injury.



**Figure 1** Percentages of TSCI according to age-groups by cause of injury, Tianjin, China from 2004 to 2008.

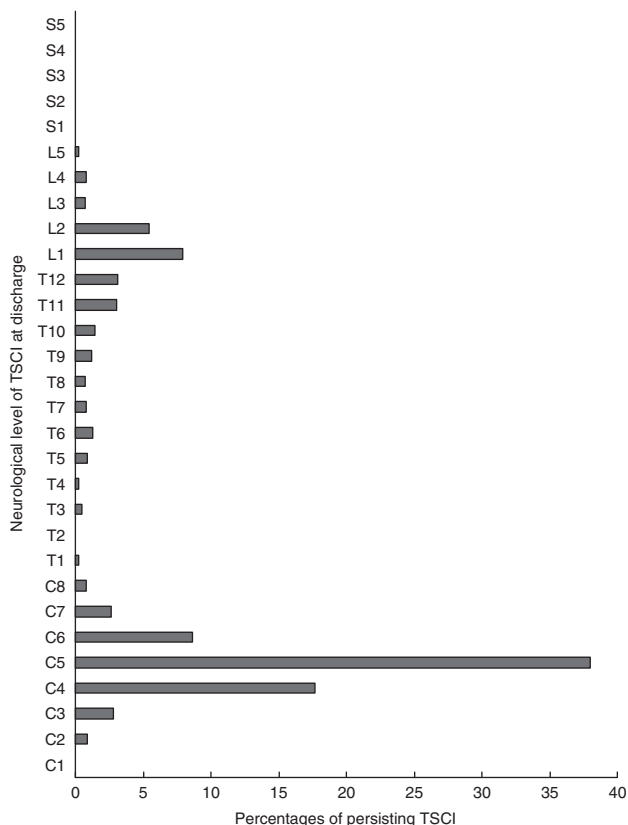
accounting for 80% of the world population, is relatively less, mainly because of lack of national SCI registers system in these countries.<sup>11</sup> To our knowledge, national or local epidemiological study of SCI has not been made previously in China.

A constant increase in incidence rate of TSCI was observed in China for these 5 years. Compared with some other developing and developed countries,<sup>3–8</sup> the incidence rate was higher. Moreover, with China's huge population and rapid development, the number of TSCIs would be high and be increasing fairly rapidly.

The sex distribution (male/female) of TSCI was 5.63:1, which was much higher than that in an early epidemiological study in a China's hospital (1.73:1).<sup>12</sup> This may be explained by the fast development of Chinese economy. Different from the early 10 years, although more women go out to work instead of staying home as housewives, men are more engaged in work, such as trucks driver, high-rise building worker, which exposes themselves to more dangerous environments than women.

As for age, the mean age of patients in our study was 46.0 years. In previous epidemiological study for SCI cases admitted in Tongji Hospital of China, mean age was 42.2 years.<sup>12</sup> In reports from other developing countries, mean ages of SCI were much lower, for example, Jordan–33.0,<sup>8</sup> Turkey–35.5,<sup>6</sup> and Iran–31.0.<sup>13</sup> The difference might be explained by ageing of the general population in China.

MVCs were the leading cause of TSCI in developed countries in the few last decades,<sup>2,5,7,14</sup> However, in our study, falls were the main causes of TSCI, similar to that of other developing countries.<sup>15,16</sup> Low falls were more common in those over 75 years of age (80.0% in this age group), followed by those in 61- to 75-year group (70.2%). As the ageing society coming, the number of low falls-induced TSCI would increase gradually. MVCs, the second cause, were



**Figure 2** Percentage of persisting TSCI by neurological level at discharge.

**Table 2** Number of TSCI according to the level and completeness of SCI, by cause of injury in Tianjin, China from 2004 to 2008

Cause of injury	Complete tetraplegia (n = 126)	Incomplete tetraplegia (n = 496)	Complete paraplegia (n = 93)	Incomplete paraplegia (n = 154)
MVC	57 (45.2%)	176 (35.5%)	33 (35.5%)	30 (19.5%)
Low fall	42 (33.3%)	251 (50.6%)	5 (5.4%)	29 (18.8%)
High fall	20 (15.9%)	36 (7.3%)	40 (43.0%)	72 (46.8%)
Struck by object	5 (4.0%)	21 (4.2%)	12 (12.9%)	17 (11.0%)
Sport-related	0	2 (0.4%)	0	0
Assault	0	7 (1.4%)	2 (2.2%)	3 (1.9%)
Work accident	1 (0.8%)	3 (0.6%)	0	3 (1.9%)
Other	1 (0.8%)	0	1 (1.1%)	0

Abbreviations: MVC, motor vehicle collision; SCI, spinal cord injury; TSCI, traumatic spinal cord injury.

responsible for 296 cases, 34.1% of all cases with TSCI. The incidence rates due to MVCs were highest in the 16- to 30-year group, followed by those in the 31- to 45-year group. Long-time fatigue driving on the highway and driving without the use of a seatbelt were the main reasons of MVCs. In total, 55 cases (6.3%) were associated with struck by object, most of which were injured during working. We

also found in China that two cases with TSCI resulted from complication in massage treatment of traditional Chinese medicine.

Gunshot injury is a common cause in certain countries.<sup>8,17,18</sup> Accidental gunfire was the second largest reason for TSCI in Jordan, because firing random shots in the air was a common cultural habit during the celebrations of wedding parties in rural areas.<sup>8</sup> In China, firearms are strictly controlled, so such injury was scarce. Compared with developed countries, sport injuries were uncommon in China because of low prevalence of certain risky sports such as rugby, diving and motor racing. Both of the two cases in our study were injured because diving in a swimming pool. We expect that with the development of society and a change in lifestyle, the number of sports-related TSCIs would increase.<sup>19</sup>

Our data show that the frequency of tetraplegia is higher than paraplegia, different from some other developing countries.<sup>6,16</sup> Four-fifth of tetraplegia cases were incomplete, most of which often were associated with low falls and MVCs. Tetraplegia accounted for 90% of TSCI cases in adults older than 60 years, because of degenerative changes of the cervical spine, including spondylosis and ossification of the posterior longitudinal ligament.

Several limitations of our study should be acknowledged. On one hand, the incidence rates of TSCI were underestimated by several aspects. First, it is difficult to count the number of the cases of pre-hospital deaths. Second, several patients with severe injuries were transferred to other hospitals located in Beijing, the capital of China and roughly 137 km far from Tianjin, which possess better medical conditions. Finally, this study is based on medical records from different hospitals. About 15 cases whose medical records were incomplete were excluded. On the other hand, because our study is retrospective, the level of detail in all records was inconsistent in different hospitals. For example, in the MVCs, the role of the patient (car driver, car passenger, cyclist or pedestrian) was not clearly reported in some medical records.

### Conclusions

This retrospective study has identified TSCI cases based on diagnostic codes and review of hospital records. Our data showed that the incidence rate of TSCI has increased steadily in China during 2004–2008, 23.7 cases per million per year on average. Mean age of TSCI cases appeared to increase in the same period. Similar to other developing countries, falls were the main causes. The frequency of tetraplegia was higher than paraplegia, and most of tetraplegia cases were incomplete.

China is a developing country with large population in the world and rapid economic development in last 30 years. It is important to describe epidemiological characteristics of SCI in this country, which are partly different from other developing countries. Our study only reports the epidemiology of TSCI in Tianjin, the third largest city in China, data from other local or even national epidemiology study are

needed. Establishment of an SCI register system would facilitate the provision of a national database for epidemiological and research purposes, which would be useful for advancing the prevention and treatment of SCI.<sup>20</sup> Although it is difficult to establish a national population-based register system in such a huge developing country, we suggest designing and implementing a population-based register step by step from city or local level.

### Conflict of interest

The authors declare no conflict of interest.

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