ORIGINAL ARTICLE

Current epidemiological profile and features of traumatic spinal cord injury in Heilongjiang province, Northeast China: implications for monitoring and control

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Study design: A retrospective hospital-based study.

Objectives: Traumatic spinal cord injury (TSCI) is considered to be an important public health problem worldwide. Only a few studies concerning the regional epidemiological characteristics of TSCI have been published in China. The purpose is to evaluate the epidemiological characteristics of TSCI in Heilongjiang province in northeast China.

Setting: The Second Affiliated Hospital of Harbin Medical University and the Fifth Hospital of Harbin City, Heilongjiang province.

Methods: Information of 232 patients who suffered from TSCI was gathered from their charts between January 2009 and December 2013. Information on sociodemographic variables was collected from each chart, including the patient's age, sex, occupation, injury time, causes and extent of injury.

Results: The average age of patients with TSCI was 45.35 ± 14.35 years. The male/female ratio was 4:1. The incidence of TSCI increased gradually with age and peaked in the 46- to 60-year-old age category. The most common occupation was farm laborer (35.34%). Motor vehicle collisions, followed by falls, were found to be the leading cause of TSCI. Furthermore, the majority of TSCI patients (76.29%) suffered a cervical injury.

Conclusion: The present study reveals that TSCI is an issue in the province, and it should not be ignored. Our results provide preliminary evidence and theoretical basis for developing an integrated control program for TSCI.

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INTRODUCTION

Traumatic spinal cord injury (TSCI) is considered as a devastating clinical condition that results in varying extents of neurological deficits such as short-term or permanent sensory and motor problems.¹ TSCI patients may suffer from somesthesia and reduced or no locomotion below the level of injury, which can present a lifelong challenge that brings with it a high economic burden on their families and society.² TSCI is considered to be an important public health problem worldwide.³ However, there has been no definitive treatment for TSCI, thus far making the development of prevention strategies critical for minimizing the adverse impact of this devastating injury.⁴ Epidemiological studies may be used not only to identify high-risk groups for TSCI, but they may also provide useful information that could be used to develop preventative measures and intervention strategies.⁵ Thus, it is imperative to carry out epidemiological studies to provide a basis for effective disease control planning and monitoring.

Epidemiological studies of TSCI have been reported in many countries throughout the world including Europe, North American, Australia and some Asian countries.⁶ Due to different methods of derivation, dates of publication and other factors such as mortality rates and limitations of cases, there is a relatively broad variation of

incidence rates of TSCI among distinctive geographic regions. In the North Americans, the incidence rate varied from 20.7 to 83.0, and in Europe the estimated incidence rates varied from 8.0 to 130.6.⁷ In Asia, the incidence rates ranged from the highest value of 61.6 per million (Taiwan) to the lowest value of 12.06 per million (Anatolia, Turkey).¹ Currently, only a few previous studies concerning the regional epidemiological characterization of TSCI have been published in China, which focused on Tianjin, Anhui, Guangzhou and Beijing (Table 1 and Figure 1). Furthermore, prevention efforts and treatment options are relatively limited.⁵ To the best of our knowledge, no previous study has ever focused on Heilongjiang province, northeast China. Many factors have an important role in the epidemiological characteristics of different regions, including economic conditions, socioeconomic conditions, human behaviors, politics, environmental factors and cultural traditions.⁸ Thus, it is necessary to further evaluate the epidemiological characteristics associated with incidences of TSCI in Heilongjiang province.

In this study, the information of TSCI inpatients was gathered and analyzed from their charts between January 2009 and December 2013. The aim of this study was to analyze the current epidemiological features and trends of TSCI patients in Heilongjiang province to

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Table 1 The prevalence profile of traumatic spinal cord injury (TSCI) in China

Location	Region	Study	Incidence period	Case source	Sample size
Tianjin	North	Feng <i>et al.</i> ⁸	1998–2009	Records data from hospital	239
Anhui	East	Wang <i>et al.</i> ⁵	2007–2010	Records data from hospital	761
Guangzhou	South	Yang <i>et al.</i> ¹⁴	2003–2011	Records data from hospital	3832
Beijing	North	Hua <i>et al.</i> ¹⁵	2001–2010	Records data from hospital	561

Figure 1 The map of TSCI investigated in China. A full color version of this figure is available at the *Spinal Cord* journal online.

provide guidance and a basis for preventive strategies and the effective application of medical resources to reduce regional TSCI incidence.

MATERIALS AND METHODS

Ethics statement

This study was approved by the Ethics Committee of Harbin Medical University.

The written informed consent was obtained from all participants including from parents/guardians of children under 18 years before medical records were reviewed. The objectives, procedures and potential risks were explained to all participants. Research assistants collected all the required data from the charts, concealed any identifiable details about the patients and recorded these blind data in a privacy-enhanced database.

Location and participants

With a population of 38 million people, Heilongjiang province is located in the northeast of mainland China. The winters are cold and snowy, and the summers are hot and rainy. Harbin City is the capital. The information of 232 TSCI patients who were referred to the Second Affiliated Hospital of Harbin Medical University and the Fifth Hospital of Harbin City in Heilongjiang province was gathered from the charts in the hospital during January 2009 and December 2013. The information included the patient's age, sex, occupation,

injury time, causes and extent of injury. Patient data were divided into four age categories: 0–15, 16–30, 31–45, 46–60 and ≥ 61 years of age. Occupations were categorized as farmer, worker, civil servant, student, retired and other (unemployed individuals and self-employed individuals).

Standards

Spinal cord injury was defined according to its international definition, which states that it is the occurrence of an acute lesion on the neural elements in the spinal canal (spinal cord and cauda equina), resulting in temporary or permanent sensory deficits, motor deficits or bladder/bowel dysfunction.⁹ Cases were confirmed as incidences of TSCI based on a clear history of traumatic injury, magnetic resonance imaging and physical examination. All of the participants in the study had all of the criteria for TSCI.

On the basis of neurological deficits, the neurologist classified the injuries as cervical, thoracic, lumbar and sacral, according to the International Standard of Neurological Classification of Spinal Cord Injury, American Spinal Injury Association (ASIA)-ISCoS impairment scale that was used for assessing the severity of motor and sensory functions.¹⁰

The cause of TSCI included motor vehicle collisions (MVCs), falls (low fall, <1 m; high fall, ≥ 1 m), falling objects, sport-related injury, blunt-force trauma, head collisions against objects and others. Complete TSCI was defined as the loss of sensory and motor function in the lowest sacral segments.¹¹

Incomplete TSCI was defined as the partial loss of sensory and/or motor function below the point of injury, including the lowest sacral segments.¹¹

Statistical analysis

Statistical analysis was conducted using SPSS software (version 10.0 for Windows; SPSS, Inc., Chicago, IL, USA). Categorical and continuous data were reported in the form of proportion and mean $\pm$ s.d., respectively.

RESULTS

General demographic characteristics of TSCI patients

Table 2 shows the general demographic characteristics of TSCI patients. Out of the patients, 186 (80%) were male and 46 (20%) were female. The male-to-female ratio was 4:1. Average patient age was 45.35 ± 14.35 years (specifically, 45.07 ± 14.11 years for men and 46.5 ± 15.40 years for women). The youngest patient was 18 years old and the oldest was 82 years old. The incidence of TSCI increased with age and peaked in groups within the 46–60 age range and subsequently declined in the 61 years and older age group (Table 3). Regarding geographical distribution, the majority of patients came from urban areas accounting for 73.71% of all TSCI patients. The most common occupation among these TSCI patients was farm laborer (35.34%) followed by retired individuals (21.98%). The other occupational groups included civil servants (15.95%), workers (10.78%), students (6.47%) and others consisting of unemployed individuals and self-employed individuals who together accounted for 9.48% of the total patients. Furthermore, during 2009–2013, the season with the highest peak of TSCI cases was autumn (31.03%).

Cause of TSCI

Table 4 showed the etiology of TSCI in Heilongjiang province within the approximate 5-year period between January 2009 and December 2013. Ultimately, MVCs were the leading cause (42.67%) of TSCI followed by falls (36.21%). In addition, low falls and high falls accounted for 22.41% and 13.79% of TSCI, respectively.

Table 2 Characteristics and demographics of patients with traumatic spinal cord injury (TSCI)

Variable	Subcategory	No. of patients	Percentage
Total		232	
Gender	Male	186	80.17
	Female	46	19.83
Age	0–15	0	0
	16–30	41	17.67
	31–45	74	31.90
	46–60	85	36.64
	61+	32	13.79
Environment	Rural	61	26.29
	Urban	171	73.71
Season	Spring	37	15.95
	Summer	68	29.31
	Autumn	72	31.03
Occupation	Winter	55	23.71
	Farmer	82	35.34
	Workers	25	10.78
	Civil servants	37	15.95
	Students	15	6.47
	Retired	51	21.98
	Other ^a	22	9.48

^aOther included unemployed individuals and self-employed individuals.

Falling objects accounted for only 7.33%. It was noted that 12 cases resulted from sports-related injury (5.17%), including 9 cases caused by winter sports. The proportion of MVCs accounting for the etiology of TSCI indicated an increasing trend during this period, whereas other causes seemed to fluctuate throughout the 5 years.

As shown in the Table 3, MVCs were the leading causes in the 46- to 60-year age groups. For ≥ 46 -year age groups, low fall was the most common cause. Furthermore, TSCI resulting from the sport-related injury occurred over the 16- to 60-year-old groups.

Table 5 shows the relationship between occupation and type of injury. MVCs were the leading cause of injury for the farmers. High fall was the common etiology for the workers.

Level of injury

Analysis of the presented data indicates that the majority of TSCI patients (177, 76.29%) suffered a cervical injury followed by thoracic injury (24, 10.34%). In addition, some TSCI patients might have experienced more than one level of injury. For example, some TSCI patients had both cervical and thoracic cord injuries (3.88%) or both thoracic and lumbar cord injuries (4.74%), respectively. There were no patients suffering from both lumbar and sacral injury.

The correlation between the injury level and the cause of injury is shown in Table 6. Different mechanism of injury resulted in various levels of injury. For example, thoracic cord injuries were mainly caused by MVC (41.67), whereas lumbosacral cord injuries were mainly caused by low falls (45.45%).

Severity of TSCI

Assessment results using the ASIA grading system is shown in Table 7. Out of all TSCI patients, 14.22% suffered from complete motor and sensory deficit (ASIA A), 15.09% patients exhibited complete motor deficit with some remaining sensory function (ASIA B), 32.76% patients exhibited inefficient motor function (ASIA C) and 37.93% patients exhibited useful remaining motor function (ASIA D).

Incomplete tetraplegia was the major consequence suffered by TSCI patients (63.36%). Almost 13% of patients suffered from complete tetraplegia, 5.17% suffered from complete paraplegia and 18.53% suffered from incomplete paraplegia.

Treatment of TSCI

Regarding treatment of the TSCI patients, 22 cases received decompression treatment, 23 cases received decompression and internal fixation, 85 cases were treated by decompression followed

Table 3 Analysis of the etiologies and age distribution among the traumatic spinal cord injury (TSCI) patients

Etiologies	Age					Total
	0–15	16–30	31–45	46–60	60+	
Motor vehicle collisions	0	17	29	43	10	99
High fall	0	7	13	9	3	32
Low fall	0	5	11	18	18	52
Collision of head	0	4	7	6	0	17
Blunt-force trauma	0	1	4	2	0	7
Falling objects	0	2	4	1	1	8
Pierce	0	3	2	0	0	5
Sport-related injury	0	2	4	6	0	12
Total	0	41	74	85	32	232

Table 4 Etiologies of patients with traumatic spinal cord injury (TSCI) in Heilongjiang province from 2009 to 2013

Etiologies	2009		2010		2011		2012		2013		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Motor vehicle collisions	12	36.36	19	41.30	23	38.33	26	47.27	19	50	99	42.67
High fall	4	12.12	6	13.04	9	15	8	14.55	5	13.16	32	13.79
Low fall	11	33.33	9	19.57	15	25	9	16.36	8	21.05	52	22.41
Collision of head	4	12.12	3	6.52	6	10	3	5.45	1	2.63	17	7.33
Blunt-force trauma	0	0	2	4.35	0	0	3	5.45	2	5.26	7	3.02
Falling objects	1	3.03	3	6.52	3	5	0	0	1	2.63	8	3.45
Pierce	0	0	2	4.35	1	1.67	2	3.64	0	0	5	2.16
Sport-related injury	1	3.03	2	4.35	3	5	4	7.27	2	5.26	12	5.17
Total	33	100	46	100	60	100	55	100	38	100	232	100

Table 5 Analysis of the etiologies and the occupation

Etiologies	Occupation					
	Farmer	Workers	Civil servants	Students	Retired	Other ^a
Motor vehicle collisions	39	4	25	9	15	99
High fall	13	8	1	3	6	32
Low fall	19	4	4	0	13	52
Collision of head	8	3	0	0	6	17
Blunt-force trauma	0	4	0	0	3	7
Falling objects	1	2	0	0	4	8
Pierce	1	0	1	1	2	5
Sport-related injury	1	0	6	2	2	12
Total	82	25	37	15	51	232

^aOther included unemployed individuals and self-employed individuals.

by internal fixation and fusion, whereas 102 cases were treated without surgical intervention (that is, hyperbaric oxygen therapy, rehabilitation therapy and traction).

DISCUSSION

TSCI can lead to motor, sensory and autonomic dysfunction, all of which can have great impact on the individual and their families. In order to prevent and minimize the consequences of TSCI, a deeper understanding of the epidemiology of TSCI is imperative. This will assist in the implementation of preventive measures and reasonable allocation of medical resources.^{12–14} Despite some research that has been conducted on the prevalence of TSCI in China (Table 1), there have not been any regional estimates of the incidence or epidemiological characteristics of TSCI in Heilongjiang province, northeast China. Social and economic circumstances of Heilongjiang province are different relative to other areas of China. Compared with the southern region, it has few cities of economic and political importance. Furthermore, at the agricultural province, farmers account for the majority, of laborers, accompanied by lower health insurance, education, household income levels and less urban areas. These factors result in reduced access to quality health care. In addition, the low temperature in the province lasts for several months, accompanied with cold and snow. Therefore, it is imperative to further evaluate the epidemiological characteristics of this province.

This is the first retrospective study of TSCI patients in Heilongjiang province. A total of 232 TSCI inpatients were investigated from 2009 to 2013. Our findings showed that TSCI, a devastating and debilitating condition, should not be neglected in this province and may contribute to the development of preventative measures and intervention strategies that could be adjusted and implemented in this region.

In the present study, the male/female ratio of TSCI patients was ~4:1, which was similar to a study in Tianjin but higher compared with studies in Anhui, Beijing, Guangdong and Iceland, demonstrating that males account for the majority of TSCI patients.^{5,8,13–15} This may be related to different lifestyles between men and women in China. The men have a responsibility to feed their family, hence they are more likely to engage in high-risk work such as construction or cargo hauling,¹⁴ whereas women are more inclined to engage in relatively low-risk occupations such as being an officer or a housewife.

The mean age of TSCI patients was 45.35, which is similar to the survey in Tianjin and Guangdong^{8,14} but older than that in Turkey¹⁶ and Saudi Arabia.¹⁷ This contrast may be attributed to different social and cultural backgrounds. Unfortunately, the highest proportion of TSCI in Heilongjiang province is noted in the 46–60 age category, followed by the 31–45 age category. Chinese people in the 46–60 age category bear much financial responsibility. Thus, they typically work harder than others subjecting themselves to higher-risk situations. This phenomenon increases their likelihood to suffer from work-related TSCI making the 46- to 60-year-old individuals a high-risk population that would most benefit from treatment and preventative measures against this form of injury.

MVC was the primary cause of TSCI in Heilongjiang province during 2009–2013, accounting for 42.67% of all TSCI cases. These results were similar to those reported in Canada¹⁸ and Spain.¹⁹ Interestingly, surveys conducted in Tianjin (1998–2009) and Anhui (2007–2010) in the past 10–20 years suggested that falls were the leading cause.^{5,8} The difference may be attributed to the rapid development of the automobile industry in China, which has led to a sustained increase in the number of motor vehicles in the past 5 years. This phenomenon was also seen in a Beijing survey, suggesting that transportation accidents had replaced falls as the primary cause of TSCI.¹⁵ In Heilongjiang province, with the economic growth, the number of motor vehicles in rural areas is also consistently increasing. Some motor vehicles are not equipped with air bags and people have no motivation to use safety belts, and here is a lack of traffic safety awareness. Moreover, there are faulty transportation facilities and lack of strict traffic safety regulations. Some of the country roads are under

Table 6 Analysis of the etiologies and segment of the injury among the traumatic spinal cord injury (TSCI) patients

Etiologies	The level of the injury									
	Cervical cord		Cervico-thoracic combined cord		Thoracic cord		Thoracolumbar combined cord		Lumbosacral cord	
	No.	%	No.	%	No.	%	No.	%	No.	%
Motor vehicle collisions	81	45.76	2	22.22	10	41.67	4	36.36	2	18.18
High fall	21	11.86	1	11.11	4	16.67	3	27.27	3	27.27
Low fall	40	22.60	6	66.67	1	4.17	0	0	5	45.45
Collision of head	15	8.47	0	0	1	4.17	1	9.09	0	0
Blunt-force trauma	5	2.82	0	0	2	8.33	0	0	0	0
Falling objects	6	3.39	0	0	1	4.17	1	9.09	0	0
Pierce	2	1.13	0	0	3	12.5	0	0	0	0
Sport-related injury	7	3.95	0	0	2	8.33	2	18.18	1	9.09
Total	177	100	9	100	24	100	11	100	11	100

Table 7 Analysis of severity of the injury of traumatic spinal cord injury (TSCI) patients

Variable	Subcategory	No. of patients	Percentage
ASIA scale	A	33	14.22
	B	35	15.09
	C	76	32.76
	D	88	37.93
Severity	IQ	147	63.36
	CQ	30	12.93
	IP	43	18.53
	CP	12	5.17

Abbreviations: ASIA, American Spinal Injury Association; CP, complete paraplegia; CQ, complete tetraplegia; IP, incomplete paraplegia; IQ, incomplete tetraplegia.

construction, and the speed limits are not strictly enforced in this province. As factors likely contribute to the high proportion of TSCI attributed to MVCs, the Chinese government should focus on reinforcing transportation safety and improving traffic management, especially in this province.

The three most common TSCI-associated occupations were farmer, worker and civil servant, respectively, suggesting that these three are high-risk occupations. However, previous reports from Guangdong,¹⁴ Tianjin⁸ and Turkey²⁰ showed that unemployed individuals and workers were the most common at-risk groups for TSCI. A possible explanation for this difference may be attributed to the contrasting economic and political environments associated with these regions. Another possible reason is that Heilongjiang province is one of the biggest provinces in China that is well-known for its farming, as it contains a higher proportion of individuals with agriculture-related occupations making them more susceptible to TSCI than individuals of any other occupation.

Falling (high falls and low falls) was the second most common cause of TSCI. The proportion of falling-associated TSCI was lower than that reported in Turkey and south Asia. This can potentially be explained by differences in habits and customs. Few people sleep on the tops of houses, use their necks to carry heavy loads or climb trees in this Chinese province.^{1,15,21} According to our data, jumping from a high place is commonly seen among farmers and workers in the 31–45 age range. On the other hand, low fall injuries such as slips or falling

objects were common in age groups older than 46. In patients older than 61, low falls was the leading cause of injury. TSCIs from low falls in the elderly are increasing in developed countries with aging populations.²² One possible explanation for this observation in this province is the prolonged winter season, which results in snow accumulation and icy roads, pavement and stairs. Another potential reason may be the prevalence of osteoporosis and degenerative joint disease among the elderly, which may make them more susceptible to injury.

It should be noted that sport-related injuries appear, even though high-risk sports such as diving and gymnastics are less popular in China relative to developed countries.²³ Because of the winter weather of Heilongjiang province and changes in sports concepts, ice and snow sports have become very popular in this province. Moreover, Heilongjiang province also has several ski resorts, one of which is the largest field in China. Skiing has become a popular sport among young individuals in the winter months. However, the lack of experience and protective measures while participating in such winter sports may explain the increasing frequency of TSCI in this category. Thus, TSCI resulting from sports-related incidents should be addressed in this province.

Understanding the severity of TSCI could help the development of treatment options and preventative measures. Using the ASIA-ISCoS scale shows that the majority of TSCI patients are in ASIA C and D and tetraplegia categories in this 5-year study period. The same phenomenon was reported in Guangdong province.¹⁴ Using epidemiological information may improve the treatment and/or mediate the effective prevention of TSCI.²²

This study has several limitations. First, as is the case with most other previously published reports, only the information of TSCI patients who were admitted to hospitals was included. Information on patients who died before reaching hospitals was not collected. Second, the number of studied subjects was relatively limited. Finally, some TSCI patients did not report back to hospitals after being discharged. Thus, further work is necessary to increase the frequency of patient follow-up in order to assess their quality of life after treatment.

In summary, our study highlights that TSCI remains a serious public health problem in Heilongjiang province. Our data suggests that farming is an occupation with a high risk of TSCI. MVC was the primary cause of TSCI. Furthermore, the annual number of MVC-induced TSCI incidences has increased in Heilongjiang

province. Recently, sport-related injuries appear to have increased significantly. We suggest improving work safety, adding helmets for the workers, enforcing transportation safety and improving traffic management. Our results provide preliminary evidence and a theoretical basis for implementation of an integrated TSCI preventive program. Future studies that would lead to injury prevention policies and management of TSCI should be considered the next steps in an integrated TSCI prevention program.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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