



## FACTORS AFFECTING LENGTH OF STAY IN HOSPITAL OF PATIENTS WITH TRAUMATIC SPINAL CORD INJURY IN CHINA

Zhenrong ZHANG, MD<sup>1</sup>, Fangyong WANG, MD<sup>1,2</sup> and Yao WU, MD<sup>1</sup>

From the <sup>1</sup>School of Rehabilitation Medicine, Capital Medical University and <sup>2</sup>Beijing Bo'ai Hospital, China Rehabilitation Research Center, Beijing, China

**Objective:** To investigate factors associated with length of stay in hospital of patients with traumatic spinal cord injury in China, based on recent data spanning a period of 10 years.

**Methods:** The study was conducted in the China Rehabilitation Research Center, Beijing, which is the largest rehabilitation hospital in China. Associated variables were statistically analysed, including sex, age, marital status, patient's home address, and payment method as demographic variables, and cause of injury, severity of injury, level of injury, spasticity, osteoporosis, neurogenic bladder, and complications as clinical variables. Univariate analysis and multiple linear regression analysis were used to determine the association between length of stay and these variables.

**Results:** A total of 2,110 participants were included in this study. Median length of stay in hospital was 113.5 days. Longer length of stay correlated significantly with higher age, single status, being struck by an object, motor vehicle collision, complete injury, and complications. Patients whose injury resulted from a fall from a low height, those with neurogenic bladder, and/or patients of older age had shorter lengths of stay.

**Conclusion:** Analysis of data for patients with traumatic spinal cord injury, spanning a recent period of 10 years in China, shows that close attention should be paid to those patients with osteoporosis, spasticity, complete injury, injury caused by object striking or motor vehicle collision, patients with single status, or who are in the age range 15–29 years. Active measures should be taken to reduce length of stay in patients with complications, such as urinary tract infection, respiratory infection, or neuropathic pain.

**Key words:** trauma; spinal cord injury; length of stay; China; rehabilitation.

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Correspondence address: Fangyong Wang, School of Rehabilitation Medicine, Capital Medical University and Beijing Bo'ai Hospital, China Rehabilitation Research Center, Beijing, China. E-mail: wfybeijing@163.com

Injury of the osseous structures and disco-ligamentous components of the spinal column often leads to spinal cord injury (SCI), which is incurable and costly for impacted individuals, their families and society (1). A

### LAY ABSTRACT

This study investigated factors associated with length of stay of in hospital of patients with traumatic spinal cord injury in China, based on recent data spanning period of 10 years. Associated variables were statistically analysed, including sex, age, single status, patient's home address, and payment method as demographic variables, and cause, severity, level of injury, spasticity, osteoporosis, neurogenic bladder, and complications as clinical variables. Univariate analysis and multiple linear regression analysis were used to detect the association between length of stay and these variables. A total of 2,110 participants were included in the study. Median length of stay in hospital was 113.5 days. Longer length of stay was significantly correlated with being older, single status, being struck by an object, motor vehicle collision, complete injury, and complications. Patients whose injury resulted from fall from a low height, those with neurogenic bladder, and/or patients of older age had shorter lengths of stay. Close attention should be paid to those patients with osteoporosis, spasticity, complete injury, injury caused by being struck by an object or motor vehicle collision, patients with single status, or who are in the age range 15–29 years. Active measures should be taken to reduce length of stay in patients with complications, such as urinary tract infection, respiratory infection, or neuropathic pain.

previous investigation of acute traumatic spinal cord injury (TSCI) in 2002 in Beijing, China found that the annual incidence was 60.6 per million (2). Data for other cities in China are scarce. Length of stay (LOS) in hospital is of great importance to patients and their family members, as increased length of hospital stays result in increased medical costs.

In general, developing countries lack a national system of SCI registers. Large-scale studies of LOS in patients with SCI have not been reported in China from a national perspective (3). The aim of this study was to investigate factors affecting LOS of patients with TSCI in China, based on recent 10-year data, and to provide reference data for policy-making.

### METHODS

#### Subjects and setting

This study was conducted in the China Rehabilitation Research Center (CRRC), which is the first and largest national rehabilita-

tion centre in China, and is the only Grade 3A general hospital and rehabilitation hospital in China. In the past 30 years, more than 10,000 patients with SCI from all over China have been admitted to the CRRC. Patients with TSCI who were admitted from 1 January 2010 to 31 December 2019 were retrospectively reviewed and analysed. Cases resulting from non-traumatic injury were excluded.

#### Measures and definition

The LOS included the length of time a patient stayed in the rehabilitation centre, from the first date of admission to the date of final discharge. After undergoing surgery or treatment in the emergency ward, patients would be transferred to the rehabilitation ward for rehabilitation training. Data were extracted from the centre's database and examined. Associated variables were statistically analysed, including sex, age, patient's home address, marital status, and payment method as demographic variables, and cause of injury, severity of injury, level of injury, spasticity, osteoporosis, neurogenic bladder, and complications as clinical variables. All variables were obtained from the database of SCI in the CRRC. Categorical variables included demographic variables and clinical variables, while continuous variables were age and LOS.

Patients were grouped according to age: 0–14, 15–29, 30–44, 45–59, and 60 years or older. The causes of SCI included high fall (from a height  $\geq 1$  m), low fall (from  $< 1$  m), motor vehicle collision (MVC), being struck by an object and other injuries. The severity of injury was divided into complete and incomplete injury, according to the American Spinal Injury Association (4) Impairment Scale (5) (AIS grade A for complete SCI, AIS grade B, C and D for incomplete SCI). Based on dual energy X-ray absorptiometry, bone mass  $> 2.5$  standard deviations (SD) below the young mean value would be diagnosed as osteoporosis (6).

Complications closely correlated with TSCI included intestinal dysfunction, urinary tract infection, neuropathic pain, respiratory infection, deep venous thrombosis (DVT), pressure ulcers, and orthostatic hypotension. Neuropathic pain is caused by a lesion or disease of the somatosensory system, which, here, refers to SCI (7). Orthostatic hypotension is a decrease in systolic blood pressure of 20 mmHg or more, or a reduction in diastolic blood pressure of 10 mmHg or more, on changing body position from a supine position to an upright posture, regardless of the presence of symptoms (8). After consultation with the specialist department, the doctors made the diagnosis and the more senior doctors reviewed it according to the above definitions.

The payment method was divided into "patients' own expense" and "others". "Patients' own expense" means that they had to pay all of the medical expenses. "Others" means that patients had Basic Medical Insurance for Urban Residents and Urban Employees, New Rural Cooperative Medical Insurance, or other commercial medical insurance, or are entitled to a free medical service (9).

#### Statistical analyses

All statistical analyses were performed by Statistical Product and Service Solutions (version 25.0 Inc., Chicago, IL, USA). The LOS was log-transformed to make it conform to normal distribution according to Kolmogorov–Smirnov's test, then used as outcome variable. One-way analysis of variance and *t*-test of 2 independent samples were performed to find significant differences between subgroups.

Multiple linear regression analysis was used to explore the association between LOS and these associated factors. Associated variables for the univariate analysis with  $p$ -value  $\leq 0.1$  were subject to a regression test. Stepwise selection methods were used to extract the significant independent variables contributing to LOS for patients with TSCI.  $p$ -values  $< 0.05$  were used as the criteria for inclusion in the linear regression equation.

## RESULTS

A total of 2,110 patients were included in this study. The median age of patients was 38 years (interquartile range (IQR) 26.75–49 years; men 39.2 years, women 31.7 years,  $p < 0.001$ ), with a range of 2–85 years, 61.2% of subjects were aged between 30 and 59 years. The ratio of males to females was approximately 3.55:1.00, with males as 78.0% and females as 22.0%. The median LOS in the rehabilitation unit was 113.5 days (IQR 53–235 days). The characteristics of the patients with TSCI are summarized in Table I.

LOS for the subgroups, and the factors associated with prolonged hospitalization in the univariate analysis are summarized in Table I. LOS was significantly correlated with older age, single status, cause of injury, severity of injury, spasticity, osteoporosis, neurogenic bladder, and complications (intestinal dysfunction, urinary tract infection, neuropathic pain, respiratory infection, DVT, pressure ulcers, and orthostatic hypotension) ( $p < 0.05$ ).

The results of association between LOS and independent variables from the multivariable analysis are shown in Table II. Patients with osteoporosis, urinary tract infection, respiratory infection, neuropathic pain, spasticity, complete injury, caused by object striking or MVC, single, age 15–29 years, had significantly longer LOS ( $p < 0.05$ ), compared with patients without those factors. Patients with neurogenic bladder, older age, and low falls, had a shorter LOS, compared with those without these factors ( $p < 0.01$ ). Other complications, sex, regions, level of injury, and payment method were excluded from the regression equation.

## DISCUSSION

TSCI leads to motor and sensory dysfunction and a range of autonomous deficits (10). China, the largest developing country in the world, has experienced both rapid economic development and increased population growth in recent years. This study presents data for cases from the CRRC, the largest SCI institute in China, which admits cases from across the country. Except for one study from a local hospital in Tianjin with only 631 cases, no such study has reported LOS in China previously (11). An investigation in the Netherlands found

**Table I.** Logarithm analysis of original data of the factors for length of stay (LOS)

Variables	n (%)	Mean (SD)	EXP (Mean)	Median (IQR)	Statistic*	p-value
Sex					t = 0.543	0.587
Male	1,646 (78.0)	4.70 (1.27)	110.2	116 (53–243.5)		
Female	464 (22.0)	4.67 (1.16)	106.3	105 (53–217)		
Age					F = 10.480 <sup>a</sup>	< 0.001
0–14 years	137 (6.5)	4.56 (1.29)	95.9	106 (45–223.5)		
15–29 years	544 (25.8)	4.90 (1.23)	134.0	137 (64–284.5)		
30–44 years	691 (32.7)	4.73 (1.26)	113.6	118 (57–245)		
45–59 years	600 (28.4)	4.61 (1.25)	100.5	100.5 (48–217.75)		
≥ 60 years	138 (6.5)	4.20 (1.06)	66.4	67 (30–138)		
Single status					t = 3.564	< 0.001
Yes	541 (25.6)	4.86 (1.27)	128.9	130 (60.5–261)		
No	1,569 (74.4)	4.64 (1.24)	103.3	104 (50–223)		
Patient's home address					F = 1.233	0.286
North China	977 (46.3)	4.69 (1.24)	108.9	112 (53.5–228)		
East China	439 (20.8)	4.77 (1.17)	117.9	124 (57–240)		
Central China	258 (12.2)	4.77 (1.31)	117.8	125 (61–262)		
Northeastern China	193 (9.1)	4.55 (1.37)	94.9	102 (38–222.5)		
Northwestern China	145 (6.9)	4.56 (1.29)	95.1	96 (41.5–249.5)		
Southwest China	79 (3.7)	4.72 (1.12)	112.3	102 (58–224)		
South China	19 (0.9)	4.49 (1.53)	88.9	115 (75–240)		
Payment method					t = 1.595	0.111
Patients' own expense	1,117 (52.9)	4.73 (1.23)	113.9	120 (57–247)		
Other's expense	993 (47.0)	4.65 (1.27)	104.4	103 (49–217.5)		
Cause of injury					F = 15.101 <sup>b</sup>	< 0.001
MVC	661 (31.3)	4.81 (1.33)	123.1	126 (58–264)		
Low fall	248 (11.8)	4.27 (1.10)	71.6	75 (31–150.5)		
High fall	638 (30.2)	4.66 (1.13)	105.3	112 (57–214.25)		
Being struck by an object	293 (13.9)	5.01 (1.29)	150.5	168 (77.5–338)		
Others	270 (12.8)	4.53 (1.27)	92.9	96 (43–191)		
Severity					t = 5.335 <sup>c</sup>	< 0.001
Complete	1,029 (48.8)	4.84 (1.21)	126.7	132 (64–265.5)		
Incomplete	1,081 (51.2)	4.55 (1.27)	95.0	97 (43.5–202.5)		
Level of injury					t = 1.113 <sup>c</sup>	0.266
Tetraplegia	843 (40.0)	4.66 (1.3)	105.3	104 (47–220)		
Paraplegia	1,267 (60.0)	4.72 (1.21)	112.0	118 (57–246)		
Spasticity	376 (17.8)	4.99 (1.29)	147.6	137.5 (66.3–309.25)	t = 5.177	< 0.001
Osteoporosis	369 (17.5)	5.35 (1.25)	209.8	214 (96–475)	t = 11.360	< 0.001
Neurogenic bladder	1,075 (50.9)	4.81 (1.19)	122.8	123 (61–259)	t = 4.377	< 0.001
Complications						
Intestinal dysfunction	833 (39.5)	4.89 (1.18)	132.5	132 (64.5–275)	t = 5.753	< 0.001
Urinary tract infection	739 (35.0)	5.09 (1.19)	162.5	160 (77–335)	t = 11.008	< 0.001
Neuropathic pain	625 (29.6)	4.98 (1.22)	146.0	141 (69.5–326.5)	t = 6.976	< 0.001
Respiratory infection	301 (14.3)	5.19 (1.15)	180.3	177 (86.5–396.5)	t = 7.605	< 0.001
DVT	227 (10.8)	4.85 (1.13)	127.7	121 (69–228)	t = 2.174	0.031
Pressure ulcers	213 (10.1)	4.89 (1.31)	133.2	144 (61–328.5)	t = 2.442	0.015
Orthostatic hypotension	113 (5.4)	5.19 (1.21)	180.1	159 (84.5–372.5)	t = 4.387	< 0.001
Hyponatraemia	59 (2.8)	4.89 (1.08)	133.6	132 (67–226)	t = 1.250	0.211

\*Independent samples t-test (t) or one-way analysis of variance (F) (performed on log-transformed LOS). <sup>a</sup>A Bonferroni post hoc test revealed significant differences between age 0–14 and 15–29, 15–29 and ≥ 60, 45–59, 15–29 and ≥ 60, 30–44 and ≥ 60, 45–59 and ≥ 60 years ( $p < 0.05$ ). All other subgroups were not significantly different from each other. <sup>b</sup>A Bonferroni post hoc test revealed significant difference between high fall and low fall, high fall and being struck by an object, low fall and MVC, low fall and being struck by an object ( $p < 0.05$ ). All other subgroups were not significantly different from each other. <sup>c</sup>On admission. EXP: expected value; IQR: interquartile range; MVC: motor vehicle collision; SD: standard deviation; DVT: deep venous thrombosis.

**Table II.** Multiple regression analysis of the factors for length of stay (LOS)

Variables	Unstandardized coefficients (B)	Standardized coefficients (β)	Definition
Osteoporosis	0.571	0.174	No = 0, Yes = 1
Urinary tract infection	0.415	0.158	No = 0, Yes = 1
Respiratory infection	0.346	0.097	No = 0, Yes = 1
Being struck by an object	0.331	0.092	No = 0, Yes = 1
Neuropathic pain	0.229	0.084	No = 0, Yes = 1
Motor vehicle collision	0.207	0.077	No = 0, Yes = 1
Severity of the injury	0.171	0.068	Incomplete = 0, Complete = 1
Single status	0.180	0.063	No = 0, Yes = 1
Spasticity	0.164	0.050	No = 0, Yes = 1
Age 15–29 years	0.135	0.047	No = 0, Yes = 1
Neurogenic bladder	-0.175	-0.070	No = 0, Yes = 1
Age 60 years and over	-0.342	-0.068	No = 0, Yes = 1
Low fall	-0.185	-0.048	No = 0, Yes = 1

Dependent variable: In LOS;  $t = 2.304$ ,  $p = 0.021$ .

that median LOS was 240 days (IQR 164–322 days), which was longer than the LOS in CRRC (12). Another multi-centre investigation in Australia found that the median rehabilitation LOS of SCI cases was 138 days (IQR 88–212 days) (13). After the initial rehabilitation treatment in CRRC, some patients were transferred to local primary hospitals or nearby community hospitals to continue rehabilitation training. However, data regarding patient transfer were not available.

Univariate and multivariate analyses showed that patients in the age range 15–29 years had longer LOS, while those aged 60 years and over had shorter LOS, which might relate to the cause of injury and severity of injury in patients in different age groups (14). In the current study cohort, injury in 44.9% of patients aged 60 years and over was caused by low fall, while 35.1% of patients in the age range 15–29 years were injured by high fall, and 37.1% by MVC. As for severity of injury, 16.7% of patients aged 60 years or over had complete injury, while 55.7% of patients in the age range 15–29 years had complete injury.

It has been reported that being single significantly increases the risk of pressure ulcers in patients with TSCI. TSCI is a huge obstacle to the future employment of patients, and it also decreases the likelihood of getting married (15). Patients who receive intensive care from their spouse may improve quickly in activities of daily living (ADL) and have reduced LOS.

In both univariate and multivariate analysis, payment method showed little correlation with LOS. However, because China's medical insurance system is different from that of countries in the western world, it is difficult to make comparisons between them. This result can therefore serve only as an understanding and reference for China's national conditions. However, it can be concluded that China must invest more in the rehabilitation of patients with SCI (16), because 52.9% of patients bear all rehabilitation costs themselves. A national unified programme of social security for SCI rehabilitation should be put forward as soon as possible.

The results of this study support that patients with complete TSCI at the time of admission had longer LOS, in both univariate analysis and multiple linear regression analysis. A study in Canada also supported this conclusion (17). Patients with complete TSCI had higher risks of complications than those with incomplete injuries, which may lead to longer LOS (18).

The cause of injury may have a greater impact on patients' LOS. Combining the results of one-way analysis of variance (ANOVA) and multiple linear regression, it can be inferred that patients with injuries resulting from a low fall may have shorter LOS, while patients with injuries resulted from a MVC or being struck by an object tend to have longer LOS. The latter was more

likely to be a high-energy trauma, and it is also more likely to cause more serious injuries, such as motor complete TSCI, leading to longer LOS (19). Among patients with TSCI caused by high falls and MVCs, 53.3% and 50.1% of patients had complete injuries, respectively. However, the proportion of patients with injuries resulting from a low fall was only 23.8% in the study cohort. Thus, patients with more severe injuries resulting from high falls and MVCs could explain the longer LOS of patients with the 2 causes.

Spasticity is a consequence of TSCI, and osteoporosis may coexist with TSCI. Among the included participants, 6.5% were elderly, and they were more likely to have osteoporosis (20). After TSCI, patients were confined to wheelchairs with little movement, and were at high risk of osteoporosis. Even a minor injury, such as a low fall, may cause spinal fracture and SCI in patients with osteoporosis (17). Both spasticity and osteoporosis prolonged LOS in hospital.

Patients with TSCI often have complications, whether they are hospitalized in the acute or rehabilitation period or after being discharged from the hospital (21, 22). It has been shown in previous studies that patients with complications after TSCI may have longer LOS (11, 23). The current study demonstrates that urinary tract infection, respiratory infection, and neuropathic pain influenced the LOS. Therefore, future studies must focus on these complications in order to shorten the LOS of patients with TSCI. A meta-analysis showed that the incidence of pressure injury in cases of SCI was 22% in developing countries vs 27% in developed countries from 2000 to 2009 (24). Participants with pressure ulcers had longer LOS in univariate analysis, but in multivariable analysis, pressure ulcers had little effect on LOS (25). These factors may be mixed with severity of the injury to cover up the influence of associated factors on LOS in multiple linear regression analysis.

#### *Study limitations*

This study had several limitations. First and foremost, it was a retrospective study and, therefore, the accuracy and completeness of documentation in the medical notes was assumed. Secondly, this study was conducted in a single geographical area in China, and therefore it may not be possible to make generalizations based on current results about TSCI in other countries or even the rest of China. Thirdly, the relationship between LOS and time from traumatic event to surgery were not interpreted in this study, although these factors would have contributed to the recovery of injury and the analyses of LOS. Finally, the current study only examined the effect of the epidemiological and clinical factors on LOS and did not identify correlation between

these factors (e.g. AIS grade, surgery, causes of injury, and complications). Further research to address the above issues is thus required.

### Conclusion

This study examined the factors affecting the LOS of patients with TSCI, based on recent 10-year data from China. This study also provides valuable information for future prospective studies in China with regard to better understanding the factors associated with the rehabilitation LOS for inpatients after TSCI. At the same time, rehabilitation has become a key health strategy of the 21st century (26). Thus, more attention should be paid to prevent and control complications during the rehabilitation of cases of TSCI, especially for those with complete TSCI.

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