Research Article

Factors Associated With In-Hospital Outcomes of Traumatic Spinal Cord Injury: 10-year Analysis of the US National Inpatient Sample

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Abstract

Introduction: Traumatic spinal cord injury (SCI) is a life-altering event. Motor vehicle accidents and falls are common causes of traumatic SCI, and SCI outcomes may be affected by patients' ages and injury sites. This study aimed to investigate the factors associated with unfavorable in-hospital outcomes, focusing on the impact of patients' ages and SCI lesion sites.

Methods: Data of 25,988 patients hospitalized with traumatic SCI in the US National Inpatient Sample (NIS) database from 2005 to 2014 were extracted and analyzed. Univariate and multivariate logistic regression analyses were performed to determine the factors associated with SCI outcomes, including in-hospital deaths, adverse discharge, and prolonged hospital stays.

Results: Multivariate analysis revealed that the oldest ages (>65 years) were significantly associated with increased in-hospital mortality compared with the youngest ages at all lesion sites (cervical, odds ratio [OR]: 5.474, 95% confidence interval [CI]: 4.465 to 6.709; thoracic, OR: 5.940, 95% CI: 3.881 to 9.091; and lumbosacral, OR: 6.254, 95% CI: 2.920 to 13.394). Older ages were also significantly associated with increased adverse outcomes at all sites (cervical, OR: 2.460, 95% CI: 2.180 to 2.777; thoracic, OR: 2.347, 95% CI: 1.900 to 2.900; and lumbosacral, OR: 2.743, 95% CI: 2.133 to 3.527). Intermediate ages (35 to 64) were also significantly associated with increased in-hospital death and adverse discharge at cervical and thoracic SCIs, but not at lumbosacral sites.

Discussion: For hospitalized patients with traumatic SCI, older age independently predicts worse in-hospital outcomes, with greatest effects seen in patients aged 65 years and older. Study findings suggest that extra vigilance and targeted management strategies are warranted in managing SCI patients aged 65 years and older during hospitalization.

Traumatic spinal cord injury (SCI) is a life-altering event. The motor, sensory, and autonomic systems may be adversely affected, and deficits can be permanent. Besides creating a burden for the patient and family members, the societal financial ramifications of traumatic SCI can be substantial.[1,2] Studies of patients with traumatic SCI have often used instruments by which to assess patients' quality of life, finding that the transition from being able to walk to having to use a wheelchair for mobility has a particularly adverse effect on one's quality of life, including increased levels of depression.[3,4] In addition, SCI is associated with elevated mortality rates. A Bangladesh study that investigated the survival of patients with SCI found that the 2-year survival rate was 87% for all patients, but the rate for patients who had to use a wheelchair was significantly lower (81%).[5] A study carried out in the United States, in which the data were obtained from the National Inpatient Sample (NIS) database for the years 1993 to 2012, also found that about 20% of patients died during the past 2 years of the study, 2010 to 2012.[6]

The International Standards for Neurological and Functional Classification of SCI is used to describe the level and extent of injury based on systematic examinations of motor and sensory neurological functions.[7,8] SCIs can be traumatic or nontraumatic. Since 2005, the most common traumatic SCI causes have been motor vehicle accidents (39.2%); falls (28.3%); violence, primarily gunshot wounds (14.6%); and sports (8.0%).[9] Emerging evidence, however, from longitudinal studies in Scotland and China suggests that an important shift has occurred in the most common causes of SCI over time.[2,10] SCIs from a penetrating injury tend to be worse than those from blunt-force injuries.[11,12] Nontraumatic SCIs are also common. Ankylosing spondylitis and other inflammatory diseases can lead to spinal fractures.[13,14] Other nontraumatic causes include autoimmune, infectious, neoplastic, vascular, and hereditary degenerative diseases.[15,16] Postmenopausal women aged older than 45 years who are diagnosed with osteoporosis are also at risk of vertebral fractures.[17]

Age has been found to affect the characteristics and outcomes of traumatic SCI. Traumatic SCIs from motor vehicle accidents are more common in younger patients, whereas older patients are more likely to have traumatic SCIs after accidental falls.[18] In addition, older patients have an increased risk for complications associated with care and an increased risk of mortality during hospitalization.[1,19]

Following the context of previous studies, this study aimed to investigate the clinical characteristics of traumatic SCI among different ages, factors associated with unfavorable in-hospital outcomes after traumatic SCI, and the impact of patients' ages on outcomes among given SCI sites.

Methods

Data Source

This observational, retrospective analysis extracted the data of patients hospitalized with traumatic SCI from 2005 to 2014 in the US National Inpatient Sample (NIS) database, which was developed by the US Healthcare Cost and Utilization Project (HCUP). Forty-five states participated in HCUP, and the NIS represents a 20% sample from the 1,051 participating hospitals. The continuous, longitudinal NIS database includes a core set of clinical and nonclinical information on all patients. These patients are included regardless of the source of payment so that the sample includes patients covered by Medicare, Medicaid, and private insurance, as well as patients without health insurance. The NIS also provides statistical weights that permit extrapolation of estimates of national case volumes. We obtained certificate number HCUP-890JXT09H and conformed to the data-use agreement for the NIS from HCUP.[20]

Study Population

Hospitalized patients aged 20 years and older with a diagnosis of traumatic SCI at a specified site were eligible for inclusion. Traumatic SCI was identified using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnostic codes 806.xx and 952.xx, together with codes indicating definitive traumatic causes including the following: road traffic accidents (E810~E825, E988.5, E800~E807, E840~E845, E830~E838, E826~E829, E988.6, E994), accidental falls (E880~E888, E987), struck by objects/persons (E916~918, E920~E921, E928.9, E960, E963, E966, E968, E973~978, E979, E983, E995), firearm injuries (E922~E923, E965, E970~971, E985, E990~E993, E996), and sports injuries (E927). Patients with unspecified lesion sites were excluded. Those admitted to the hospital electively were also excluded from the primary cohort.

Patients were categorized into three different age groups (<35, 35 to 64, 64+ years) in accordance with previously published studies.[21,22]

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Lesion sites of SCI were classified into cervical spine (806.0x, 806.1x, 952.0x), thoracic spine (806.2x, 806.3x, 952.1x), lumbosacral (806.4x, 806.5x, 806.6x, 806.7x, 952.2, 952.3, 952.4), and other sites using ICD-9-CM codes.

Outcome Measures and Study Variables

The primary outcome measures were in-hospital death and adverse discharge after traumatic SCI. The secondary outcome was prolonged hospital stay. Adverse discharge disposition was defined as those who were discharged to skilled nursing facilities, intermediate care, home hospice care, hospice medical facility, long-term care hospital, and certified nursing facility, whereas patients discharged to home or short-term care facility were defined as "non-adverse" discharge, as previously described.[23]

Besides age and sites of injury, other study variables included cause of injury, paralysis status, with or without (ICD-9-CM: 952.0 to 952.9) radiologic abnormality, complete (ICD-9-CM: 806.01, 806.06, 806.11, 806.16, 806.21, 806.26, 806.31, 806.36, 806.61, 806.71, 952.01, 952.06, 952.11, 952.16, 952.4) or incomplete SCI, concurrent traumatic brain injury (ICD-9-CM: 800.0 to 804.9, 850.0 to 854.1), operative spinal intervention (decompression, any fusion, or neither), and Charlson Comorbidity Index (CCI), as described previously.[24-26]

Injury severity was measured by the Injury Severity Score (ISS), which uses a novel program called International Classification of Diseases Program for Injury Categorization (ICDPIC) trauma that maps ISS from ICD-9-CM codes and has been used and validated in previous studies.[27,28] This ISS is therefore termed ICISS (International Classification of Diseases Program for Injury Categorization-calculated Injury Severity Score).

Hospital-related information was also extracted from the NIS database, including bedsize and location/teaching status. Bedsize assessed the number of short-term acute care beds set up and staffed in a hospital, and were categorized into small (<250 beds), medium (250 to 450 beds), and large (>450 beds).

Statistical Analysis

Summary statistics were performed for all variables by age groups. Continuous variables were compared by two-sample Student *t*-tests, whereas categorical variables were analyzed using Pearson χ^2 or Fisher exact tests with missing values excluded. Univariate and multivariable analyses were performed to determine the association between the study variables and in-hospital death, adverse discharge, and prolonged hospital stay. Stratified analyses were done by separating the sites of SCI to further evaluate the associations between age and clinical outcomes. The results are presented as odds ratios (ORs) and 95% confidence intervals (CIs). A two-tailed P value <0.05 was considered statistically significant. All statistical analyses were carried out using SAS 9.4 analytical software (SAS Institute, Cary, NC).

Results

Study Population

A total of 28,119 patients aged 20 years and older admitted to hospitals emergently with traumatic SCI were extracted from the NIS database from 2005 to 2014. Patients with missing data for age, sex, and main outcomes were excluded from the cohort, as well as those without codes regarding specified injury site of spinal cord. The final analytic sample included 25,988 patients.

Descriptive Statistics

The demographic and clinical characteristics of the study cohort are summarized in Table 1. Most patients were men (70.5%). Cervical spine was the most frequent site of SCI (62.0%). The frequency of cervical spine injury was lowest among patients aged 20 to 34 years (44.2%) and was highest among those aged 65 years (68.8%) or older. Most thoracic spine injuries occurred in patients aged 20 to 34 years (28.9%), and the least occurred in those aged 35 to 64 years (17.1%). The same distribution pattern was found among injuries at the lumbosacral region. The highest percentage of spinal cord injuries resulted from road traffic accidents except in the oldest patient group (>64 years), which were primarily the result of falls. Statistically significant differences were found between the three age groups in sex, cause of injury, paralysis, radiologic abnormality, type of injury, concurrent traumatic brain injury, ICISS, operative spinal interventions, CCI, hospital bedsize, and location/teaching status (all $P <$ 0.001) (Table 1).

The clinical outcomes after traumatic SCI are shown in Table 2. Total in-hospital mortality was 8.1%. The frequencies of all unfavorable outcomes (in-hospital death, adverse discharge, and prolonged length of stay) were significantly different between the three age groups (all $P <$ 0.001) (Table 2).

Associations Between Study Variables and In-Hospital Mortality

The associations between study variables and in-hospital death are summarized in Table 3. Multivariable analysis revealed that higher odds of in-hospital death was significantly associated with older age (>64 years) and intermediate age (35 to 64 years) (versus the youngest age [> 35

Table 1

Patients' Demographic and Clinical Characteristics by Age

		Age Group			
Characteristics	**Total (n = 25,988)**	**<35 (n = 5,845)**	**35–64 (n = 12,109)**	**≥65 (n = 8,034)**	***P* Value**
Sex					
Female	7,645 (29.4)	1,214 (20.8)	2,953 (24.4)	3,478 (43.3)	<0.001
Male	18,318 (70.5)	4,621 (79.1)	9,143 (75.5)	4,554 (56.7)	
Unknown/missing	25 (0.1)	10 (0.2)	13 (0.1)	2 (0.0)	
Cause of injury					
Road traffic accidents	9,962 (38.3)	3,186 (54.5)	5,280 (43.6)	1,496 (18.6)	<0.001
Accidental falls	12,503 (48.1)	1,187 (20.3)	5,263 (43.5)	6,053 (75.3)	
Struck by objects/persons	1,664 (6.4)	370 (6.3)	946 (7.8)	348 (4.3)	
Firearm injuries	1,372 (5.3)	999 (17.1)	356 (2.9)	17 (0.2)	
Sport injuries	206 (0.8)	40 (0.7)	106 (0.9)	60 (0.7)	
Multiple causes	281 (1.1)	63 (1.1)	158 (1.3)	60 (0.7)	
Site of injury					
Cervical	16,104 (62.0)	2,584 (44.2)	7,991 (66.0)	5,529 (68.8)	<0.001
Thoracic	5,163 (19.9)	1,692 (28.9)	2072 (17.1)	1,399 (17.4)	
Lumbosacral	3,160 (12.2)	1,092 (18.7)	1,289 (10.6)	779 (9.7)	
Other/multiple sites	1,561 (6.0)	477 (8.2)	757 (6.3)	327 (4.1)	
Paralysis					
Neither	23,261 (89.5)	5,223 (89.4)	10,870 (89.8)	7,168 (89.2)	<0.001
Paraplegia	902 (3.5)	311 (5.3)	392 (3.2)	199 (2.5)	
Quadriplegia	1,825 (7.0)	311 (5.3)	847 (7.0)	667 (8.3)	
Radiologic abnormality					
Absent	10,500 (40.4)	1,437 (24.6)	5,620 (46.4)	3,443 (42.9)	<0.001
Present	15,488 (59.6)	4,408 (75.4)	6,489 (53.6)	4,591 (57.1)	
Type of injury					
Incomplete injury	23,059 (88.7)	4,668 (79.9)	10,829 (89.4)	7,562 (94.1)	<0.001
Complete injury	2,929 (11.3)	1,177 (20.1)	1,280 (10.6)	472 (5.9)	
Concurrent traumatic brain injury					
Absent	19,779 (76.1)	4,225 (72.3)	9,095 (75.1)	6,459 (80.4)	<0.001
Present	6,209 (23.9)	1,620 (27.7)	3,014 (24.9)	1,575 (19.6)	
ICISS					
Mean	19.1 (12.30)	22.2 (13.18)	19.2 (12.17)	16.6 (11.23)	<0.001
Operative spinal interventions					
None	23,334 (89.8)	5,439 (93.1)	11,110 (91.7)	6,785 (84.5)	<0.001
Decompression	1,599 (6.2)	392 (6.7)	728 (6.0)	479 (6.0)	
Any fusion	1,055 (4.1)	14 (0.2)	271 (2.2)	770 (9.6)	
CCI					
0	14,632 (56.3)	4,485 (76.7)	7,455 (61.6)	2,692 (33.5)	<0.001
1	6,627 (25.5)	1,220 (20.9)	3,068 (25.3)	2,339 (29.1)	
≥2	4,729 (18.2)	140 (2.4)	1,586 (13.1)	3,003 (37.4)	
Hospital bedsize					
Small (<250)	1,156 (4.4)	182 (3.1)	454 (3.7)	520 (6.5)	<0.001
Medium (250–450)	5,101 (19.6)	1,140 (19.5)	2,351 (19.4)	1,610 (20.0)	
Large (>450)	19,412 (74.7)	4,442 (76.0)	9,140 (75.5)	5,830 (72.6)	

(*continued*)

CCI = Charlson Comorbidity Index, ICISS, International Classification of Diseases Program for Injury Categorization-calculated injury severity score

Table 1 (*continued*)

Patients' Demographic and Clinical Characteristics by Age

Characteristics	Total (n = 25,988)	Age Group			*P* Value
		<35 (n = 5,845)	35–64 (n = 12,109)	≥65 (n = 8,034)	
Unknown/missing	319 (1.2)	81 (1.4)	164 (1.4)	74 (0.9)	
Location/teaching status					
Rural	1,037 (4.0)	148 (2.5)	424 (3.5)	465 (5.8)	<0.001
Urban nonteaching	6,011 (23.1)	1,091 (18.7)	2,607 (21.5)	2,313 (28.8)	
Urban teaching	18,621 (71.7)	4,525 (77.4)	8,914 (73.6)	5,182 (64.5)	
Unknown/missing	319 (1.2)	81 (1.4)	164 (1.4)	74 (0.9)	

CCI = Charlson Comorbidity Index, ICISS, International Classification of Diseases Program for Injury Categorization-calculated injury severity score

Table 2

In-Hospital Outcomes After Traumatic SCI by Age

Characteristics	Total (n = 25,988)	Age Group			*P* Value
		<35 (n = 5,845)	35–64 (n = 12,109)	≥65 (n = 8,034)	
In-hospital death					
Died	2098 (8.1)	283 (4.8)	640 (5.3)	1,175 (14.6)	<0.001
Alive	23,871 (99.9)	5,555 (95.0)	11,461 (94.7)	6,855 (85.3)	
Unknown/missing	19 (0.1)	7 (0.1)	8 (0.1)	4 (0.1)	
Adverse discharge[a]					
No	10,508 (44.0)	2,692 (48.4)	5,641 (49.2)	2,175 (31.7)	<0.001
Yes	13,328 (55.8)	2,854 (51.3)	5,804 (50.6)	4,670 (68.1)	
Unknown/missing	54 (0.2)	16 (0.3)	24 (0.2)	14 (0.2)	
Prolonged length of stay[b]					
No[d]	11,331 (47.4)	2,223 (40.0)	5,450 (47.5)	3,658 (53.3)	<0.001
Yes	12,559 (52.6)	3,339 (60.0)	6,019 (52.5)	3,201 (46.7)	

SCI = spinal cord injury
[a] Cases that died in hospital were excluded. The remaining number of patients was 23,890.
[b] Defined as at or above median value of length of stays (8 days).

years], OR = 5.72, 95% CI: 4.83 to 6.774; OR: 1.454, 95% CI: 1.243 to 1.702, respectively), male sex (versus female, OR: 1.402, 95% CI: 1.255 to 1.566), injuries caused by firearms (versus road traffic accidents, OR: 1.988, 95% CI: 1.568 to 2.520), with quadriplegia (versus neither paraplegia or quadriplegia, OR: 1.66, 95% CI: 1.403 to 1.964), with concurrent traumatic brain injury (versus without, OR: 2.155, 95% CI: 1.943 to 2.390), higher ICISS (OR: 1.031, 95% CI: 1.026 to 1.035), underwent any fusion (versus no operative intervention, OR: 1.266, 95% CI: 1.022 to 1.569), or CCI score ≥2 (versus CCI = 0, OR: 1.169, 95% CI: 1.010 to 1.352). Lower odds of in-hospital death was significantly associated with accidental falls (versus road traffic accidents, OR: 0.874, OR: 0.779 to 0.981), injury from being struck by objects/persons (versus road traffic accidents, OR: 0.719, 95% CI: 0.556 to 0.931), lesion at thoracic or lumbosacral spine (versus cervical, OR: 0.465, 95% CI: 0.402 to 0.536; OR: 0.248, 95% CI: 0.195 to 0.316), and other sites (versus cervical, OR: 0.595, 95% CI: 0.489 to 0.724) (Table 3).

Associations Between Study Variables and Adverse Discharge

Multivariate analysis revealed that higher odds of adverse discharge was associated with older ages and intermediate ages compared with youngest ages (OR: 2.428, 95% CI: 2.215 to 2.662; OR: 1.195, 95% CI: 1.111

Table 3

Associations Between Patients' Characteristics and In-Hospital Outcomes

	In-Hospital Death		Adverse Discharge		Prolonged Hospital Stay	
Variables	**OR (95% CI)**	**aOR (95% CI)**	**OR (95% CI)**	**aOR (95% CI)**	**OR (95% CI)**	**aOR (95% CI)**
Age group						
<35	Reference	Reference	Reference	Reference	Reference	Reference
35–64	1.096 (0.950-1.265)	**1.454 (1.243-1.702)**	0.970 (0.910-1.035)	**1.195 (1.111 to 1.286)**	**0.764 (0.717-0.814)**	1.027 (0.956-1.104)
≥65	**3.365 (2.941-3.849)**	**5.72 (4.83-6.774)**	**2.025 (1.882-2.179)**	**2.428 (2.215-2.662)**	**0.578 (0.540-0.619)**	**0.783 (0.718-0.854)**
Sex						
Female	Reference	Reference	Reference	Reference	Reference	Reference
Male	**1.194 (1.079-1.321)**	**1.402 (1.255-1.566)**	**0.921 (0.870-0.974)**	1.026 (0.965-1.091)	**1.308 (1.240-1.380)**	**1.197 (1.129-1.269)**
Cause of injury						
Road traffic accidents	Reference	Reference	Reference	Reference	Reference	Reference
Accidental falls	0.982 (0.894-1.079)	**0.874 (0.779-0.981)**	**1.287 (1.218-1.361)**	**1.203 (1.127-1.285)**	**0.637 (0.604-0.671)**	**0.81 (0.761-0.862)**
Struck by objects/ persons	**0.498 (0.390-0.635)**	**0.719 (0.556-0.931)**	**0.746 (0.670-0.830)**	**0.878 (0.782-0.985)**	**0.543 (0.489-0.603)**	**0.684 (0.611-0.766)**
Firearm injuries	0.895 (0.725-1.105)	**1.988 (1.568-2.520)**	**1.700 (1.503-1.923)**	**1.671 (1.455-1.920)**	**2.109 (1.858-2.393)**	**1.686 (1.467-1.938)**
Sport injuries	<0.001 (<0.001->999.99)	<0.001 (<0.001->999.999)	**0.533 (0.401-0.709)**	**0.664 (0.490-0.900)**	**0.295 (0.217-0.401)**	**0.428 (0.309-0.591)**
Multiple causes	**0.560 (0.326 to 0.963)**	0.587 (0.333-1.036)	1.255 (0.981-1.607)	**1.321 (1.019-1.711)**	0.926 (0.730-1.176)	1.022 (0.796-1.313)
Level of injury						
Cervical	Reference	Reference	Reference	Reference	Reference	Reference
Thoracic	**0.551 (0.484-0.627)**	**0.465 (0.402-0.536)**	**1.271 (1.189-1.358)**	0.979 (0.905-1.059)	**1.493 (1.402-1.591)**	**1.133 (1.052-1.220)**
Lumbosacral	**0.229 (0.181-0.289)**	**0.248 (0.195-0.316)**	**0.765 (0.708-0.827)**	**0.783 (0.717-0.855)**	**1.123 (1.041-1.212)**	**1.106 (1.015-1.206)**
Other sites	0.917 (0.766-1.098)	**0.595 (0.489-0.724)**	**1.529 (1.364-1.714)**	1.088 (0.958-1.235)	**2.150 (1.927-2.398)**	**1.37 (1.214-1.545)**
Paralysis						
Neither	Reference	Reference	Reference	Reference	Reference	Reference
Paraplegia	0.802 (0.609-1.055)	1.132 (0.837-1.530)	**2.519 (2.152-2.947)**	**1.881 (1.584-2.234)**	**2.403 (2.080-2.777)**	**1.556 (1.325-1.826)**
Quadriplegia	**2.073 (1.805-2.381)**	**1.66 (1.403-1.964)**	**2.709 (2.404-3.053)**	**2.106 (1.846-2.403)**	**2.285 (2.062-2.531)**	**2.086 (1.858-2.342)**
Radiologic abnormality						
No	Reference	Reference	Reference	Reference	Reference	Reference
Yes	**2.288 (2.063 to 2.538)**	3.02 (2.693 to 3.387)	**1.584 (1.503 to 1.668)**	**1.625 (1.527 to 1.728)**	**1.949 (1.854 to 2.050)**	**1.676 (1.581 to 1.777)**
Type of injury						
Incomplete	Reference	Reference	Reference	Reference	Reference	Reference

(*continued*)

aOR = adjusted odds ratio, CI = confidence interval, CCI = Charlson comorbidity index, ICISS, International Classification of Diseases Program for Injury Categorization-calculated injury severity score, OR = odds ratio
Significant values are shown in bold font.

Table 3 (*continued*)

Associations Between Patients' Characteristics and In-Hospital Outcomes

	In-Hospital Death		Adverse Discharge		Prolonged Hospital Stay	
Variables	**OR (95% CI)**	**aOR (95% CI)**	**OR (95% CI)**	**aOR (95% CI)**	**OR (95% CI)**	**aOR (95% CI)**
Complete	**2.176 (1.941-2.439)**	0.934 (0.772-1.130)	**2.927 (2.656-3.226)**	**1.645 (1.452-1.864)**	**3.208 (2.939-3.501)**	**1.247 (1.110-1.401)**
Concurrent traumatic brain injury						
Absent	Reference	Reference	Reference	Reference	Reference	Reference
Present	**2.429 (2.215-2.664)**	**2.155 (1.943-2.390)**	**1.187 (1.115-1.262)**	**1.136 (1.06-1.218)**	**1.461 (1.379-1.547)**	**1.228 (1.151-1.311)**
ICISS						
	1.033 (1.030 to 1.035)	**1.031 (1.026 to 1.035)**	**1.034 (1.031 to 1.037)**	**1.028 (1.024 to 1.033)**	**1.044 (1.041 to 1.047)**	**1.027 (1.024 to 1.031)**
Operative spinal interventions						
None	Reference	Reference	Reference	Reference	Reference	Reference
Decompression	**0.580 (0.459-0.733)**	**0.481 (0.376-0.615)**	**2.146 (1.913-2.407)**	**1.797 (1.592-2.028)**	**4.835 (4.241-5.513)**	**4.723 (4.123-5.411)**
Any fusion	**1.902 (1.590-2.275)**	**1.266 (1.022-1.569)**	**1.890 (1.637-2.182)**	**1.187 (1.008-1.399)**	**1.132 (1.000-1.281)**	**1.271 (1.102-1.465)**
CCI						
0	Reference	Reference	Reference	Reference	Reference	Reference
1	**1.214 (1.088-1.355)**	0.892 (0.785-1.013)	**1.737 (1.633-1.848)**	**1.354 (1.262-1.453)**	**1.332 (1.257-1.412)**	**1.317 (1.231-1.410)**
≥2	**1.965 (1.763-2.189)**	**1.169 (1.010-1.352)**	**2.119 (1.970-2.280)**	**1.504 (1.372-1.648)**	**1.197 (1.121-1.279)**	**1.502 (1.378-1.636)**

aOR = adjusted odds ratio, CI = confidence interval, CCI = Charlson comorbidity index, ICISS, International Classification of Diseases Program for Injury Categorization-calculated injury severity score, OR = odds ratio
Significant values are shown in bold font.

Table 4

Associations Between Patients' Ages and In-Hospital Deaths by Site of SCI

	In-Hospital Death[a]		
Variable	**Cervical (n = 16,104) aOR (95% CI)**	**Thoracic (n = 5,163) aOR (95% CI)**	**Lumbosacral (n = 3,160) aOR (95% CI)**
Age group, yr			
<35	Reference	Reference	Reference
35-64	**1.331 (1.096-1.616)**	**2.055 (1.435-2.941)**	1.817 (0.951-3.475)
≥65	**5.474 (4.465-6.709)**	**5.940 (3.881-9.091)**	**6.254 (2.920-13.394)**

aOR = adjusted odds ratio, CI = confidence interval, SCI = spinal cord injury
[a] Multivariate analysis after adjusting for age, sex, cause of injury, paralysis, radiologic abnormality, type of injury, concurrent traumatic brain injury, ICISS (International Classification of Diseases Program for Injury Categorization-calculated injury severity score), operative spinal interventions, and CCI
Significant values are shown in bold font.

to 1.286). Compared with road traffic accidents, accidental falls (OR: 1.203, 95% CI: 1.127 to 1.285), firearm injuries (OR: 1.671, 95% CI: 1.455 to 1.920), and other causes of injury (OR: 1.321, 95% CI: 1.019 to 1.711) had higher odds of adverse discharge. The following variables were also significantly associated with higher odds of adverse discharge: paraplegia and quadriplegia (versus neither, OR: 1.881.95% CI:

Table 5

Associations Between Patients' Ages and Adverse Discharge by the Site of SCI

Variable	Adverse Discharge[a] Cervical (n = 16,104) aOR (95% CI)	Thoracic (n = 5,163) aOR (95% CI)	Lumbosacral (n = 3,160) aOR (95% CI)
Age group, yr			
<35	Reference	Reference	Reference
35-64	**1.196 (1.079-1.325)**	**1.304 (1.119-1.520)**	1.075 (0.895-1.292)
≥65	**2.460 (2.180-2.777)**	**2.347 (1.900-2.900)**	**2.743 (2.133-3.527)**

aOR = adjusted odds ratio, CI = confidence interval, SCI = spinal cord injury
[a] Multivariate analysis after adjusting for age, sex, cause of injury, paralysis, radiologic abnormality, type of injury, concurrent traumatic brain injury, ICISS (International Classification of Diseases Program for Injury Categorization - calculated injury severity score), operative spinal interventions, CCI.
Significant values are shown in bold font.

1.584 to 2.234; OR: 2.106, 95% CI: 1.846 to 2.403), with radiologic abnormality (versus without, OR: 1.625, 95% CI: 1.527 to 1.728), with complete spinal injury (versus incomplete, OR: 1.645, 95% CI: 1.452 to 1.864), with concurrent traumatic brain injury (versus no concurrent traumatic brain injury, OR: 1.136, 95% CI: 1.060 to 1.218), higher ICISS (OR: 1.028, 95% CI: 1.024 to 1.033), decompression and any fusion (versus neither, OR: 1.797, 95% CI: 1.592 to 2.028; OR: 1.187, 95% CI: 1.008 to 1.399), and higher CCI score (CCI ≥2 versus CCI = 0, OR: 1.354, 95% CI: 1.262 to 1.453; CCI = 1 versus CCI = 0, OR: 1.504, 95% CI: 1.372 to 1.648). On the contrary, compared with road traffic accidents, struck by objects/person, and sport injuries (OR: 0.878, 95% CI: 0.782 to 0.985; OR: 0.664, 95% CI: 0.490 to 0.900) had lower odds of adverse discharge. Lumbar sacral injury site (versus cervical, OR: 0.783, 95% CI: 0.717 to 0.855) also had lower odds of adverse discharge.

Associations Between Study Variables and Prolonged Hospital Stay

Multivariate analysis revealed that ages 35 to 64 years (versus < 35 years, OR: 1.027, 95% CI: 0.956 to 1.104) had higher odds for prolonged hospital stay, but not for ages 65 years and older (versus <35 years, OR: 0.783, 95% CI: 0.718 to 0.854). Significantly higher odds of prolonged hospital stay was associated with being male (versus female, OR: 1.197, 95% CI: 1.129 to 1.269), firearm injuries (versus road traffic accidents, OR: 1.686, 95% CI: 1.467 to 1.938), thoracic injury (versus cervical, OR: 1.133, 95% CI: 1.052 to 1.220), lumbosacral (versus cervical, OR: 1.106, 95% CI: 1.015 to 1.206), and other sites (versus cervical, OR: 1.370, 95% CI: 1.214 to 1.545), with quadriplegia (versus neither, OR: 1.556, 95% CI: 1.325 to 1.826), or paraplegia (versus neither, OR: 1.556, 95% CI: 1.325 to 1.826), with radiologic abnormality (versus without, OR: 1.676, 95% CI: 1.581 to 1.777), with complete spinal injury (versus incomplete, OR: 1.247, 95% CI: 1.110 to 1.401), with concurrent traumatic brain injury (versus without, OR: 1.228, 95% CI: 1.151 to 1.311), with higher ICISS (OR: 1.027, 95% CI: 1.024 to 1.031), underwent decompression (versus neither, OR: 4.723, 95% CI: 4.123 to 5.411), any fusion (versus neither, OR: 1.271, 95% CI: 1.102 to 1.465), and higher CCI (CCI = 1 versus CCI = 0, OR: 1.317, 95% CI: 1.231 to 1.410; CCI ≥2 versus CCI = 0, OR: 1.502, 95% CI: 1.378 to 1.636).

Associations Between Age and Outcomes by the Site of Spinal Cord Injury

After adjusting for variables associated with in-hospital mortality or adverse discharge, the oldest age (>65 years) was significantly associated with increased in-hospital mortality compared with the youngest age (20 to 34 years) among all lesion sites (cervical, OR: 5.474, 95% CI: 4.465 to 6.709; thoracic, OR: 5.940, 95% CI: 3.881 to 9.091; and lumbosacral, OR: 6.254, 95% CI: 2.920 to 13.394). The oldest age was also associated with increased adverse discharge (cervical, OR: 2.460, 95% CI: 2.180 to 2.777; thoracic, OR: 2.347, 95% CI: 1.900 to 2.900; and lumbosacral, OR: 2.743, 95% CI: 2.133 to 3.527). In addition, the intermediate age group (35 to 64) had significantly higher odds of in-hospital death and adverse discharge among injuries at cervical and thoracic spine, but not among lumbosacral injuries (Tables 4 and 5).

Discussion

In the present study, advanced age was significantly associated with both in-hospital death and adverse discharge. After adjusting for all confounders, including injury severity, being of older age (>65 years) was significantly associated with a more than five-time risk of in-hospital death and more than twice the risk of adverse discharge compared with being age 35 years or younger, and this remained true among all lesion sites of traumatic SCI. Ages 35 to 64 years were significantly associated with increased risk of death and adverse discharge among cervical and thoracic SCI compared with similar injuries among those <35 years of age, but no significant differences were found among those with lumbosacral injury.

In a recent Australian study of patients with traumatic SCI,[1] the patients were divided into only two age groups (≤64 and ≥65), and significant differences were found between the age groups, including that a significantly higher proportion of patients in the older group had longer length of stay (LOS) and increased mortality. However, the authors did not include the site of injury in their analysis, which is considered one of the most important variables that need to be addressed.

In the present study, the in-hospital mortality rate was 8.1%. Jain et al,[6] who also used the NIS data but from earlier time periods, reported a rate of 6.6% for the years 1997 to 2000 and a rate of 7.5% for the years 2010 to 2012. Those authors also found that the mortality rate increased with increasing age, although for patients aged older than 85 years this trend reversed.

In a study that focused on the epidemiology of traumatic spinal fracture in China,[18] the authors found a significant difference in LOS in patients injured by falls, depending on whether the falls were from a high or low height; the authors also found significant differences in LOS between three groups of ascending impairment severity classified as ASIA A; ASIA B, C, or D; and ASIA E according to the American Spinal Injury Association classification, but the most common injury of patients at all impairment levels was thoracic spine injury. In a Korean study of patients with SCI, the authors analyzed the data from all hospital admissions over a specific time and found that LOS was longer when the injuries involved traffic accidents compared with other causes.[29]

The present study found that cervical spinal cord injuries were the most common, and this was true for all three age groups. A recent study by Li et al[2] of patients with traumatic SCI in China also reported that injuries at the cervical level were the most common, although there was a decrease during the years 2008 to 2016 (84.4%) compared with 1999 to 2007 (68.9%).[2] The present study covered the years 2005 to 2014, and we did not investigate changes in injury sites over time. However, Li et al[2] speculated that the proportion of injuries at the cervical level may have decreased because in the later period there was an increased number of older patients; those authors also suggested that more patients had injuries due to degenerative diseases that affected the thoracic, lumbar, and sacral levels in addition to injuries due to falls from lower heights that were likely to affect the cervical level. Lala et al[30] attempted to enumerate the determinants of fracture risk in 70 patients with SCI and found that low areal bone mineral density at the knee and suboptimal tibia bone geometry were associated with increased fragility fractures. That study is a useful reminder that SCI is a variable in a wider range of disorders than one might recognize. Wang et al[18] found that spinal fractures at the cervical level occurred more frequently when the cause of injury was a traffic accident, but spinal fractures at the lumbar level were more common in injuries resulting from accidental falls.

The present study has several strengths that should be noted. The NIS is the largest all-payer inpatient care database in the United States. It contains data from approximately 8 million hospital admissions, and all discharges from sampled hospitals are included in the NIS database. Because the analysis was conducted using a nationally representative sample, our results can be generalized to the entire US adult cohort.

Our study also had several limitations, including that the NIS database is cross-sectional, which limits inferences of causality. In addition, because the NIS database uses the billing code system to identify the patients' medical conditions, coding errors may occur and certain severe injuries such as stenotic and spondylotic cervical spine injuries with potentially permanent neurological impairment could not be identified or included in this study. Although we have included as many confounders as possible, other confounders not reported in the NIS database such as lifestyle and behavior factors along with clinical laboratory data were not included. Finally, the NIS database provides only in-hospital outcomes; therefore, our findings cannot address the long-term health status and the need for additional hospitalizations or procedures after the index discharge. Furthermore, as Xu and Lun[31] have demonstrated, SCI complicated by cervical spine fracture contributes to the difficulty of surgical management of multilevel cervical stenosis, although the task is not considered to be insurmountable.

In conclusion, for hospitalized patients with traumatic SCI, older age independently predicts unfavorable in-hospital outcomes for mortality and discharge disposition, with the greatest effects seen in those aged 65 years and older. Findings of the present study suggest that extra vigilance and the development of better management strategies are highly warranted in caring for this SCI subgroup during hospitalization.

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