Original Article
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Association Between Trauma Center Designation and Spinal Cord Injury Admission in the USA

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Abstract

Background: After spinal cord injury (SCI), patients are seen in either trauma center emergency departments (EDs) or non-trauma center EDs, and then selectively admitted for hospitalization. The association between SCI and admission to designated trauma centers is currently unknown. In this study, we assess the trends in admission between designated trauma centers after SCI from a large multi-center nationwide registry.

Methods: In this retrospective analysis of the Nationwide Emergency Department Sample (NEDS), we identified visits with SCI from 2006 to 2014. Z-test analyses were used to compare patients diagnosed with SCI at EDs with an associated trauma center designated hospital (TC-visits) against patients diagnosed with SCI at EDs without an associated trauma center designated hospital (NTC-visits).

Results: A total of 516,716 reported visits were identified with SCI. The annual total ED visits with admission to the same hospital for patients diagnosed with SCI increased significantly from 39,129 to 50,127 from 2006 to 2014 ($P < 0.001$). From 2006 to 2014, the annual ED visits and admissions from TC-visits increased significantly from 27,781 to 43,926 and 23,445 to 35,635, respectively ($P < 0.0001$, $P < 0.0001$). However, the annual ED visits and admissions from NTC-visits did not change significantly from 23,938 to 22,107 and 15,683 to 14,493, respectively ($P = 0.09$ and $P = 0.1$). Throughout the entire study period, the annual total ED visits with admissions to the same hospital was significantly higher for TC-visits than NTC-visits diagnosed with SCI ($P < 0.0001$). The mean length of stay (14.1 days vs. 8.1 days), annual total in-hospital mortality (6.8% vs. 6.0%), and annual total discharges to another institution (53.8% vs. 46.8%) were significantly higher in TC-visits throughout the study period ($P < 0.001$). However, the annual total routine discharges (27.2% vs. 26.4%), annual total discharges to short-term hospital (12.4% vs. 7.2%), and annual total discharges to home health care (7.7% vs. 4.4%) were significantly higher in NTC-visits throughout the study period ($P < 0.001$).

Conclusions: Of the population of patients with SCI who visit EDs, those seen at trauma centers have a significant parallel association with incidence and patient outcome compared against those seen at non-trauma centers. Prospective research is warranted to make recommendations for required healthcare infrastructures based on an institution's trauma center designation.

Keywords: Spinal cord injury; Trauma; Trauma center; Mortality; Hospital length of stay; Disposition

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Introduction

In the USA, there are an estimated 12,500 cases of spinal cord injury (SCI) that are newly diagnosed annually [1]. SCI can result in morbid disruption of spinal cord integrity, which can negatively impact a patient's quality of life, and occasionally lead to permanent disability [2]. In the acute injury period, clinical studies are equivocal on the efficacy of various treatment paradigms on patient outcomes in the severely injured patient. However, in patients with sub-total SCI, injury with incomplete motor and/or sensory losses, early intervention and rehabilitation have demonstrated robust improvements in morbidity [3, 4]. To this end, primary trauma centers have the advantage of rapidly available multidisciplinary care teams, best suited for the care of this population. Data have suggested that primary management of traumatic SCI at level 1 trauma facilities may result in improved outcomes and shorter hospitalizations [5].

In the USA, the American College of Surgeons validates a trauma center's designation, which indicates the level of acute care that the institution can provide [6]. This designation identifies and categorizes emergency departments (EDs) and their associated hospitals as trauma centers based on their ability to staff and provide care to patients affected by a wide range of traumatic injuries [6]. Conversely, an ED and its associated hospital without trauma center designation are defined as a non-trauma center, which does not have the resources or staff to manage patients with traumatic injuries. This tiered tri-

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Table 1. Annual ED Visits and Admissions After SCI at Trauma Center (TC) and Non-Trauma Center (NTC) in the USA From 2006 to 2014

	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total annual ED visits after SCI	51,719	52,479	56,516	56,692	59,014	59,059	58,261	56,947	66,029
Total annual admissions to same hospital from ED visits after SCI	39,129 (75.67%)	39,285 (74.86%)	42,721 (75.59%)	41,837 (73.78%)	45,505 (77.11%)	44,857 (75.95%)	43,586 (74.81%)	41,965 (73.69%)	50,127 (75.92%)
TC visits after SCI	27,781	29,439	31,522	30,438	33,268	46,774	43,984	38,897	43,926
TC admissions after SCI	23,445 (84.39%)	23,848 (81.01%)	25,701 (81.53%)	24,811 (81.51%)	28,120 (84.53%)	36,678 (78.42%)	33,739 (76.71%)	29,839 (76.71%)	35,635 (81.12%)
NTC visits after SCI	23,938	23,040	24,994	26,254	25,747	12,285	14,277	18,051	22,104
NTC admissions after SCI	15,683 (65.5%)	15,437 (67%)	17,020 (68.1%)	17,026 (64.85%)	17,385 (67.52%)	8,179 (66.58%)	9,847 (68.97%)	12,126 (67.18%)	14,493 (65.57%)
P value for number of admissions after SCI	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

SCI: spinal cord injury; ED: emergency department.

age system enables greater resource concentration for patient populations requiring them and minimizes redundancy, while also systematically improving costs. However, recent reports demonstrate that socioeconomic and racial trends are associated with the severity and subsequent management of SCI [7, 8]. Additionally, small studies have identified that patients who were discharged home directly from the ED were more likely to present to a non-trauma center, suggesting the possibility of admission bias in these cases [9].

Considering the lack of data on the incidence of SCI admissions to designated trauma centers, we sought to determine the incidence and trend of SCI admissions to hospitals, and to assess the impact of designated trauma centers on this trend in the USA.

Materials and Methods

Patient selection

Using data from the Nationwide Emergency Department Sample (NEDS) we conducted a 9-year retrospective analysis of patients who were admitted with a primary diagnosis of SCI. Patient specific demographics, including age and gender, were assessed and compared. The NEDS represents the largest all-payer ED database in the USA. Our institution exempted this analysis from full review by the Institutional Review Board. Patients admitted between 2006 and 2014, with a primary diagnosis of SCI were identified by Clinical Classification Software Code 227, which included ICD-9 codes of 8064, 8065, 8068, 8069, 9072, 9522-9524, 9528, 9529, 34939, 80600-80639, 80660-80662, 80669-80672, 80679, and 95200-95219 [10].

Methods and measurements

Year-wise distribution of ED visits, hospital admissions from ED, and percentage of visits admitted to hospital from ED for patients with SCI at ED with an associated trauma center designated hospital (TC-visits) and patients with SCI at ED without an associated trauma center designated hospital (NTC-visits) were described.

Year-wise distribution of incidence, mean length of stay (LOS), annual total in-hospital mortality, annual total routine discharges, annual total discharges to short-term hospital, annual total discharges to home health care, and annual total discharges to another institution for patients with SCI at TC-visits and NTC-visits were described.

Statistical analysis

The Z-test statistic was used to compare nominal groups. Parametric data were analyzed as mean ± standard deviation (SD) with statistical significance defined as $\alpha < 0.05$. Non-parametric data were represented as mean ± interquartile range (IQR).

Results

From 2006 to 2014, a total of 516,716 reported visits were concordant with a diagnosis of SCI. Most cases (median = 41.5%, IQR = 40.5 - 43, P < 0.01) were between 18 to 44 years old, of which 74.8% were males. Overall, the annual total ED visits for all patients diagnosed with SCI in the ED increased significantly from 51,719 to 66,029, with a mean of 57,412.2 ED visits (SD = 4,161.4) occurring annually during the study period (P < 0.001). For all patients diagnosed with SCI, the annual total ED visits with admission to the same hospital increased significantly from 39,129 to 50,127 throughout the study period (P < 0.001). Throughout the study period, the total cohort did not change significantly with regards to the rate of visits per 100,000 (4.0 to 3.8, P = 0.05), the total mean LOS (13.6 days to 12.5 days, P = 0.14), or total mortality (6.21% to 6.06%, P = 0.95).

From 2006 to 2014, the annual ED visits and admissions from TC-visits increased significantly from 27,781 to 43,926 and 23,445 to 35,635, respectively (Table 1, P < 0.0001, P <

Table 2. Patient Outcomes After Spinal Cord Injury for Trauma Center (TC) and Non-Trauma Center (NTC) in the USA From 2006 to 2014

	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total annual SCI TC discharges	9,960	9,871	10,323	9,003	9,884	9,929	9,451	8,932	11,127
Total annual SCI NTC discharges	2,049	1,974	2,164	1,706	1,828	713	940	1,151	1,059
Length of stay TC	14.6	15.1	15	15	14	14	14	12.7	13
Length of stay NTC	8.8	9	8.3	8	8	7	8	8.1	7.4
P value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
In-hospital mortality									
TC	624	694	696	681	728	608	685	628	692
Percent of TC discharges	6.26%	7.03%	6.74%	7.57%	7.37%	6.13%	7.25%	7.03%	6.22%
NTC	122	92	155	133	114	*	*	*	47
Percent of NTC discharges	5.95%	4.67%	7.14%	7.79%	6.24%	*	*	*	4.45%
P value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	*	*	*	< 0.001
Routine discharge									
TC	2,871	2,669	2,901	2,409	2,470	2,752	2,328	2,191	2,817
Percent of TC discharges	28.82%	27.04%	28.10%	26.75%	24.99%	27.72%	24.63%	24.53%	25.31%
NTC	599	616	659	495	466	137	262	295	281
Percent of NTC discharges	29%	31%	30%	29%	25.49%	19.27%	27.86%	25.65%	26.50%
P value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Discharge to short-term hospital									
TC	*	*	1,083	622	729	682	643	424	813
Percent of TC discharges	*	*	10.49%	6.91%	7.38%	7%	6.80%	4.74%	7.31%
NTC	358	247	263	203	262	108	106	109	75
Percent of NTC discharges	17.47%	12.53%	12.16%	11.88%	14.34%	15%	11%	9%	7%
P value	*	*	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Discharge to another institution									
TC	5,121	5,082	5,132	4,816	5,410	5,214	5,328	5,143	6,352
Percent of TC discharges	51.42%	51.49%	49.71%	53.50%	54.73%	52.51%	56.37%	57.57%	57.09%
NTC	827	898	891	792	780	404	436	551	575
Percent of NTC discharges	40.34%	45.50%	41.16%	46.46%	42.67%	56.60%	46.41%	47.93%	54.28%
P value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Discharge to home health care									
TC	442	*	410	392	465	459	367	485	396
Percent of TC discharges	4.44%	*	3.97%	4.35%	4.71%	5%	3.89%	5.43%	3.56%
NTC	128	103	171	65	189	*	89	136	69
Percent of NTC discharges	6%	5%	8%	3.79%	10%	*	9%	12%	6%
P value	< 0.001	*	< 0.001	< 0.001	< 0.001	*	< 0.001	< 0.001	< 0.001

The numbers less than 10 are depicted with asterisks (*) for confidentiality based on the Health Care Utilization Project (HCUP) policy.

0.0001). However, the annual ED visits and admissions from NTC-visits did not change significantly from 23,938 to 22,107 and 15,683 to 14,493, respectively (Table 1, P = 0.09 and P = 0.1). Throughout the entire study period, for patients with SCI, the annual total ED visits with same hospital admissions was significantly higher for TC-visits (80.7%) than NTC-visits diagnosed with SCI (Table 1, P < 0.0001).

The mean LOS (14.1 days vs. 8.1 days), annual total in-hospital mortality (6.8% vs. 6.0%), and annual total discharges to another institution (53.8% vs. 46.8%) were significantly higher in TC-visits throughout the study period (Table 2, P < 0.001). However, the annual total routine discharges (27.2% vs. 26.4%), annual total discharges to short-term hospital (12.4% vs. 7.2%), and annual total discharges to home health care (7.7% vs. 4.4%) were significantly higher in NTC-visits throughout the study period (Table 2, P < 0.001).

Discussion

In this study, we found a significant difference in the incidence of ED visits and hospital admissions for the population of patients suffering from SCI in trauma center designated hospitals (TC-visits) compared to non-trauma center hospitals (NTC-visits). Within the population of SCI, there was a consistently higher rate or incidence in TC-visits along with parallel associations in LOS, annual total in-hospital mortality, and annual total discharges to another institution. However, NTC-visits had significant parallel associations with annual total routine discharges, annual total discharges to short-term hospital, and annual total discharges to home health care. Overall, our results may highlight differences in the patient presentation, severity of initial injury, and/or inequalities in care between the two types of institutions.

The reason for these observed differences between EDs with and without trauma center designation may be multifactorial. It is important to acknowledge that in our own study, most patients with SCI were young adult males. This is in accordance with several previous studies that also determined young adult males to be a primary cohort in SCI [9-13]. These studies suggested that in this cohort, specifically, race and socioeconomic disparities further play an influential role in hospital admissions in the population of patients diagnosed with SCI [9-13]. These studies argued that patients in this demographic comprise patients with a lower socioeconomic status who may have limited access to primary care, which may further reduce ED utilization by this population [12]. On the contrary, the existing literature also suggests that the elderly cohort is associated with decreased admission rates following SCI even though elderly patients are more susceptible to SCI from relatively low mechanisms of injury [14, 15]. These studies emphasize that patient demographics including socioeconomic status, race, age, and gender may more profoundly affect the incidence of patients diagnosed with and admitted for SCI than previously realized. While our study cannot directly compare and control for differences in the patient demographics between TC-visits and NTC-visits, it is nevertheless important to consider the impact of our own study's primary demographic in the context of our results.

In addition to patient demographic, differences in degree of injury severity likely accounts for differences in admissions and outcomes between the two institutions. Mohan et al demonstrated that physicians practicing in non-trauma centers encounter patients with moderate to severe injuries at a significantly lower rate than their trauma center physician counterparts [16]. This emphasizes the propensity for moderate-to-severe traumatic injuries to present to trauma centers. Lower SCI severity in patients seen at non-trauma centers could explain the lower mortality, shorter stays, and increased routine disposition observed in our own study. Future studies comparing the injury severity score (ISS), an established grading system for assessing traumatic severity, in these two institutions would therefore allow us to better comment on the impact of the trauma center's designation on patient outcomes. Moreover, follow-up metrics after discharge would allow us to better assess long-term outcomes in these SCI patients.

Lastly, inequalities in the level of care between TC and NTC-visits may exist. Patient signs and symptoms following SCI are highly variable, depending on the severity of injury and patient population [3-5, 14, 15, 17]. Grassner et al reported rapidly progressing paresis (49.5%) and abundance of respiratory insufficiency (26.9%) as the most common reasons for neurological intensive care unit (ICU) admission following SCI in patients [17]. However, physiologic responses are not as easily detected in certain cohorts. For example, previous investigations have demonstrated that current trauma center triage filters may under-triage and thereby decrease hospital admission rates for elderly patients with SCI. Elderly patients, with impaired autoregulation and home B-blocker use, are likely to have normal heart rates following SCI, which is more likely to lead to fewer admissions in this cohort despite the degree of injury sustained [14, 15, 18-23]. It is possible, then, that EDs with trauma center designated hospitals, with their rapidly available multidisciplinary care teams, may detect SCI signs and symptoms more readily than their non-trauma center counterparts [3-5]. This would result in higher admission rates for patients visiting ED with trauma center designation, as was identified throughout our own study. Further investigation with regards to time to admission after insult may help to evaluate differences in care at these two types of institutions.

Information involving trauma center designation and its effect on hospital admissions and patient outcomes after SCI, including mortality, may play an influential role in the process by which SCI patients choose their care providers. While several studies argued in favor of the superiority of trauma centers, highlighting significantly fewer complication rates, lower mortality, and better overall patient outcomes than non-trauma centers, our study found patients treated at trauma centers experienced a higher mortality rate and a longer LOS [24, 25-30]. We propose that a larger proportion of severe cases of SCI presented to trauma centers, which may have influenced the higher mortality rate in trauma centers for this study. The number of TC-visits significantly increased during the study period, whereas the number of NTC-visits significantly decreased. This may suggest that improved outcomes and acknowledged care at trauma centers influenced patients' choice of care over the study period.

Although our study design allows for a large dataset over a wide range of care settings, our study has several limitations that may affect the interpretation of reported findings. The NEDS does not account for number of patients, but for visits to the ED. Some patients may have had multiple visits to the ED following SCI and may have therefore been accounted for multiple times. The NEDS utilizes large sample sizes and we acknowledge the need for validation in additional datasets. Additionally, presented data may include transfers of patients from non-trauma centers to trauma centers, which could have impacted our calculations. Finally, generalizability of our study to countries other than the USA may not be possible as healthcare settings may differ. Nevertheless, information involving trauma center designation and its effect on hospital admissions and patient outcomes after SCI has significant implications on the clinical care of SCI, the financial aspects of treatment of SCI, and our understanding of healthcare resources. Future studies comparing for SCI injury severity, patient demographic factors, complications at follow up, and time to admission could provide invaluable insight into differences in care between these two care settings, as described previously.

In summary, in this large nationwide study, the yearly observation of SCI patients consistently showed that the trauma center designation of hospitals associated with EDs paralleled associations in incidence and patient outcomes. Considering the severity of this clinical condition, the outcomes of patients with this pathology is significant for both patients and healthcare institutions. In the population studied, trauma centers had a significantly higher rate of SCI incidence and hospital admission from ED. Also, the mean LOS, annual total in-hospital mortality, and annual total discharges to another institution were significantly higher in trauma centers throughout the study period. Knowing this information may be beneficial for patients diagnosed with SCI to assist in plans in regards to SCI treatment. Prospective research is warranted to make recommendations for patient care following SCI based on the trauma center designation.

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Conflict of Interest

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Informed Consent

Informed consent was not required by our institution for this study.

Author Contributions

RSE performed research including data collection, statistical analysis, created tables and wrote the paper. AD wrote the paper. AS designed research and provided expert clinical knowledge to revise critically.

Data Availability

The data supporting the findings of this study have been deposited in HCUPnet database and can be accessed at https://hcupnet.ahrq.gov/#setup.

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