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Traumatic Spinal Cord Injury in the United States, 1993–2012

Nitin B. Jain, MD, MSPH;, **Gregory D. Ayers, MS;**, **Emily N. Peterson, MS;**, **Mitchel B. Harris, MD;**, **Leslie Morse, DO;**, **Kevin C. O'Connor, MD;**, and **Eric Garshick, MD, MOH**

Department of Physical Medicine and Rehabilitation, Vanderbilt University School of Medicine, Nashville, Tennessee (Jain); Department of Orthopaedics and Rehabilitation, Vanderbilt University School of Medicine, Nashville, Tennessee (Jain); Department of Biostatistics, Vanderbilt University School of Medicine, Nashville, Tennessee (Ayers, Peterson); Department of Orthopedic Surgery, Brigham and Women's Hospital, Boston, Massachusetts (Harris); Harvard Medical School, Boston, Massachusetts (Harris, Morse, Garshick); Department of Physical Medicine and Rehabilitation, Spaulding Rehabilitation Hospital, Boston, Massachusetts (Morse, O'Connor); Channing Division of Network Medicine, Brigham and Women's Hospital, Boston, Massachusetts (Garshick); Pulmonary and Critical Care Medicine Section, Medical Service, VA Boston Healthcare System, Boston, Massachusetts (Garshick).

Abstract

IMPORTANCE—Acute traumatic spinal cord injury results in disability and use of health care resources, yet data on contemporary national trends of traumatic spinal cord injury incidence and etiology are limited.

OBJECTIVE—To assess trends in acute traumatic spinal cord injury incidence, etiology, mortality, and associated surgical procedures in the United States from 1993 to 2012.

DESIGN, SETTING, AND PARTICIPANTS—Analysis of survey data from the US Nationwide Inpatient Sample databases for 1993–2012, including a total of 63 109 patients with acute traumatic spinal cord injury.

Corresponding Author: Nitin B. Jain, MD, MSPH, Department of Physical, Medicine and Rehabilitation, Vanderbilt University School of, Medicine, 2201 Children's Way, Ste 1318, Nashville, TN 37202, (nitin.jain@vanderbilt.edu)..

Author Contributions: Dr Jain and Mr Ayers had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Jain, Harris, Morse, O'Connor.
Acquisition, analysis, or interpretation of data: Jain, Ayers, Peterson, Garshick.
Drafting of the manuscript: Jain, Ayers, Peterson, Harris, Garshick.
Critical revision of the manuscript for important intellectual content: Ayers, Peterson, Harris, Morse, O'Connor, Garshick.
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MAIN OUTCOMES AND MEASURES—Age- and sex-stratified incidence of acute traumatic spinal cord injury; trends in etiology and in-hospital mortality of acute traumatic spinal cord injury.

RESULTS—In 1993, the estimated incidence of acute spinal cord injury was 53 cases (95% CI, 52–54 cases) per 1 million persons based on 2659 actual cases. In 2012, the estimated incidence was 54 cases (95% CI, 53–55 cases) per 1 million population based on 3393 cases (average annual percentage change, 0.2%; 95% CI, −0.5% to 0.9%). Incidence rates among the younger male population declined from 1993 to 2012: for age 16 to 24 years, from 144 cases/million (2405 cases) to 87 cases/million (1770 cases) (average annual percentage change, −2.5%; 95% CI, −3.3% to −1.8%); for age 25 to 44 years, from 96 cases/million (3959 cases) to 71 cases/million persons (2930 cases), (average annual percentage change, −1.2%; 95% CI, −2.1% to −0.3%). A high rate of increase was observed in men aged 65 to 74 years (from 84 cases/million in 1993 [695 cases] to 131 cases/million [1465 cases]; average annual percentage change, 2.7%; 95% CI, 2.0%–3.5%). The percentage of spinal cord injury associated with falls increased significantly from 28% (95% CI, 26%–30%) in 1997–2000 to 66% (95% CI, 64%–68%) in 2010–2012 in those aged 65 years or older ($P < .001$). Although overall in-hospital mortality increased from 6.6% (95% CI, 6.1%–7.0%) in 1993–1996 to 7.5% (95% CI, 7.0%–8.0%) in 2010–2012 ($P < .001$), mortality decreased significantly from 24.2% (95% CI, 19.7%–28.7%) in 1993–1996 to 20.1% (95% CI, 17.0%–23.2%) in 2010–2012 ($P = .003$) among persons aged 85 years or older.

CONCLUSIONS AND RELEVANCE—Between 1993 and 2012, the incidence rate of acute traumatic spinal cord injury remained relatively stable but, reflecting an increasing population, the total number of cases increased. The largest increase in incidence was observed in older patients, largely associated with an increase in falls, and in-hospital mortality remained high, especially among elderly persons.

Traumatic spinal cord injury leads to chronic impairment and disability. Despite the substantial effects of spinal cord injury on health-related quality of life and health care spending, data on trends in incidence, etiology, and medical care of acute traumatic spinal cord injury in the United States have limited availability from contemporary nationwide studies. Prior incidence rates, including from the Spinal Cord Injury Model Systems,[1] have been calculated based on regional estimates from the 1980s.[2–14] The quantification of acute spinal cord injury incidence is essential to understand its contribution to estimates on persons with disability in the United States. Knowing trends in etiology of acute spinal cord injury would also help identify specific population groups at risk and help target preventive measures.

The objective of this study was to assess trends in national incidence, etiology, health care utilization, and in-hospital mortality in acute traumatic spinal cord injury from 1993 to 2012.

Methods

Patient Population

We used the Nationwide Inpatient Sample (NIS) databases for the years 1993 through 2012. The NIS is part of the Healthcare Cost and Utilization Project sponsored by the Agency for Healthcare Research and Quality. It is the largest all-payer inpatient database available in the United States.[15] The NIS has been extensively used to estimate population-based estimates and trends for a variety of medical conditions.[16–18] The NIS survey uses sampling techniques to ensure national representation and provides sampling weights to enable calculation of national rates. The NIS has been validated by an independent contractor and against the National Hospital Discharge Survey.[19,20] Further details about the database, sampling techniques, and validation can be found elsewhere.[15,19,20] Institutional review board exemption was granted by Vanderbilt University Medical Center; institutional review board approval was obtained from VA Boston Healthcare System and a waiver of informed consent was granted.

Acute Spinal Cord Injury Admissions—The NIS has information on primary International Classification of Diseases, Ninth Revision, Clinical Modification (*ICD-9-CM*) diagnosis and procedure codes and secondary diagnosis and procedure codes for each patient record. The Centers for Disease Control and Prevention has defined acute traumatic spinal cord injury based on a clinical and *ICD-9-CM* criterion.[21] We used the *ICD-9-CM* criterion to define cases of acute traumatic spinal cord injury. Per this criterion, cases of acute traumatic spinal cord injury included (1) records with a primary diagnosis code of acute traumatic spinal cord injury (see list of codes in eAppendix 1 in the Supplement) or (2) records with a primary diagnosis code of any form of injury (see list of codes in eAppendix 1) and a secondary diagnosis code of acute traumatic spinal cord injury. The *ICD-9-CM* codes for acute traumatic spinal cord injury included injuries to the cauda equina but did not include injuries to spinal nerve roots and spinal plexus.[10] Reliable information on degree of neurological deficits such as quadriplegia or paraplegia or extent of neurological function was not available.

We also designed a second comprehensive approach to define cases of acute traumatic spinal cord injury. This approach defined a case as existing if any of the *ICD-9-CM* diagnoses codes in the databases represented an acute traumatic spinal cord injury. Using this approach, an injury diagnosis code was not required if the record had an *ICD-9-CM* diagnosis code for acute traumatic spinal cord injury. The rationale for using the second approach was to capture patients with acute traumatic spinal cord injury who may have had other concomitant disorders such as brain injury, fractures, and shock that may have been coded as the primary *ICD-9-CM* code. Data extracted using the first, more conservative approach were used for subsequent analyses to assess age-stratified rates, etiology, complications, and procedures so as to not overestimate spinal cord injury incidence and because this approach has been previously reported.[21] Spinal cord injury captured by *ICD-9-CM* codes in our study include cervical, thoracic, and lumbosacral injuries with or without vertebral fractures.

Etiology, Complications, and Procedures—The etiology of spinal cord injury was categorized based on *ICD-9-CM* E codes (external causes of injury) into unintentional falls (henceforth referred to as falls), motor vehicle crashes, and firearm injuries. This categorization was performed based on coding guidelines from the Centers for Disease Control and Prevention[22] with minor modifications. The Healthcare Cost and Utilization Project inpatient databases have been reported to have a high level of completeness for E codes[23]. E codes were included as 1 of the 15 diagnosis codes in the NIS prior to 2003 and as separate variables with up to 4 E codes from 2003 onward. There were substantial changes to E codes in October 1994; hence, etiology was determined starting in the year 1997 for our study (1995–1996 were not used to determine etiology to allow for enough time to elapse after these substantial changes to the E codes). Within the E codes, in 2001, there were substantial changes to the E917 codes (striking against or struck accidentally [by objects or persons]). Moreover, prior to 2001, the E917 codes did not distinguish between an injury leading to a fall or not. Hence, E917 codes were not used to ascertain falls (only 1.1% of spinal cord injury records from 1993–2012 carried this code without another code for fall; see eAppendix 2 in the Supplement). We used *ICD-9-CM* codes for both traffic and nontraffic motor vehicle crashes.

ICD-9-CM procedure codes were used to identify commonly performed surgical procedures during inpatient admissions for acute spinal cord injury (see list of codes in eAppendix 2). In-hospital complication rates in acute spinal cord injury were determined using *ICD-9-CM* diagnosis codes for pulmonary embolism and infarction, deep venous thrombosis of lower extremity, and pressure ulcer (see list of codes in eAppendix 2).

Statistical Analysis

We estimated the population-based number of patients with acute traumatic spinal cord injury in the United States from 1993–2012 by using sampling weights provided in the NIS databases. Within each sampling stratum, the NIS defines sampling weights as the ratio of discharges in the American Hospital Association survey data for nonrehabilitation community hospitals to discharges in the sample.[15] We used revised NIS sampling weights, released in 2014, for each of the years.[24] We calculated standard deviations and 95% confidence intervals around the population-based point estimates using strata and cluster variables. We calculated overall and age-stratified spinal cord injury incidence rates per 1 million persons by using population estimates for a given age group and year from the US Census Bureau.[25–27] Ninety-five percent confidence intervals around incidence rates were derived by dividing 95% confidence intervals of spinal cord injury point estimates by the total US population for each strata.[28]

We also calculated the unweighted proportion of patients by spinal cord injury etiology, in-hospital complications, in-hospital mortality, surgical procedures performed, and other clinical and demographic characteristics over blocks of 3 to 5 consecutive years. In-hospital mortality includes all-cause death that resulted during the index admission. The un-weighted calculations do not provide nationally representative estimates but provide percentages among the spinal cord injury patients who were sampled. Confidence intervals for proportions of events were determined using large sample approximation to the binomial distribution.

We used joinpoint regression analysis to assess changes in spinal cord injury incidence and population-based rates. Specialized software developed by the Surveillance Research Program of the National Cancer Institute was used for this purpose.[29] Joinpoint regression summarizes the trend in rates over a period of time and assesses significant changes in slopes of linear trend using average annual percentage change (AAPC) estimated from the regression model.[30] We also present 95% confidence intervals around AAPCs using the empirical quantile method.[31] Trend analyses for unweighted proportions were made using the Armitage trend test or logistic regression. *P*<.05 was considered statistically significant for the trend tests.

Results

The total study sample consisted of 63 109 patients with acute traumatic spinal cord injury in 1993–2012. The actual number of cases with acute traumatic spinal cord injury in the NIS database increased from 2659 in 1993 to 3393 in 2012 (AAPC, 1.4%; 95% CI, 0.5%–2.3%) (Table 1). The estimated annual incidence rate was 53 cases (95% CI, 52–54 cases) per 1 million persons in 1993 and 54 cases (95% CI, 53–55 cases) per 1 million persons in 2012 (AAPC, 0.2%; 95% CI, −0.5% to 0.9%) (Figure 1 and eTable 1 in the Supplement). Age-stratified incidence rates showed a decreasing trend in younger age groups among the male population (a decrease from an estimated 144 cases/million [2405 cases] in 1993 to 87 cases/million [1770 cases] in 2012 for the 16- to 24-year-old age group [AAPC, −2.5%; 95% CI, −3.3% to −1.8%] and from 96 cases/million [3959 cases] in 1993 to 71 cases/million [2930 cases]in 2012 for the 25- to 44-year-old age group [AAPC, −1.2%; 95% CI, −2.1% to −0.3%]) (Table 2). Among the female population aged 16 to 24 years, the incidence rate decreased from 42 cases/million in 1993 to 27 cases/million in 2012 (AAPC, −1.8%; 95% CI, −3.1% to −0.5%). For both the male and female populations, a high rate of increase in spinal cord injury incidence from 1993 to 2012 was observed in elderly persons (for instance, from 84 cases/million [695 cases] to 131 cases/million [1465 cases] in men aged 65–74 years; AAPC, 2.7%; 95% CI, 2.0%–3.5%). Age- and sex-stratified numbers of cases in the databases and estimated numbers of age- and sex-stratified cases are provided in eTables 2 and 3 in the Supplement. Population estimates used to calculate incidence rates are provided in eTables 4 and 5 in the Supplement.

The etiology of spinal cord injury included falls, motor vehicle crashes, and firearm injuries in a majority of the cases from 1997 to 2012 (Figure 2). There was a significant increase in the proportion of traumatic spinal cord injuries resulting from falls between 1997 (19.3%; 95% CI, 17.9%–20.7%) and 2012 (40.4%; 95% CI, 38.7%–42.0%; *P* < .001) (eTable 6 in the Supplement). Age-stratified trends showed an increase in fall-related spinal cord injury as a proportion of total spinal cord injury cases among those aged 65 years or older between 1997–2000 (28%; 95% CI, 26%–30%) and 2010–2012 (66%; 95% CI, 64%–68%; *P* < .001) (eTable 7 in the Supplement). Spinal cord injury from firearms was one of the major contributors of spinal cord injury in the 16- to 24-year-old age group (14%–18% of cases). Motor vehicle crash was the etiology in 22.3% (95% CI, 19.7%–25.0%) of cases in 1997–2000 and in 17.9% (95% CI, 15.8%–19.9%) of cases in 2010–2012 in the 65- to 74-year-old age group, in 20.2% (95% CI, 17.5%–22.9%) of cases in 1997–2000 and in 15.4% (95% CI, 13.2%–17.6%) of cases in 2010–2012 in the 75-to 84-year-old age group, and in 11.5% (95% CI, 8.5%–14.6%) of cases in 1997–2000 and in 10.1% (95% CI, 7.8%–12.4%) of cases in 2010–2012 in those aged 85 years or older.

Some of the most commonly performed surgical procedures showed a modest increase from 1993 to 2012: for inter-vertebral disk excision, from 11.2% (95% CI, 10.6%–11.7%) to

15.9% (95% CI, 15.2%–16.6%), and for spinal canal decompression, from 10.2% (95% CI, 9.6%–10.7%) to 15.9% (95% CI, 15.2%–16.6%). The percentage of patients with spinal cord injury undergoing vena cava filter placement showed a substantial increase from 4% (95% CI, 3.5%–4.2%) in 1993–1996 to 14.5% (95% CI, 13.9%–15.0%) in 2005–2009 (Table 3). During acute care inpatient stays in 2005–2009, 1.14% (95% CI, 0.98%–1.3%) of patients had a pulmonary embolism/infarction, 2.64% (95% CI, 2.39%–2.90%) had a deep venous thrombosis, and 4.84% (95% CI, 4.52%–5.17%) had a pressure ulcer. In 2010–2012, 1.5% (95% CI, 1.27%–1.73%) of patients had a pulmonary embolism/infarction, 2.93% (95% CI, 2.61%–3.25%) had a deep venous thrombosis, and 4.55% (95% CI, 4.16%–4.94%) had a pressure ulcer.

Acute inpatient mortality was 6.6% (95% CI, 6.1%–7.0%) in 1993–1996 and 7.5% (95% CI, 7.0%–8.0%) in 2010–2012 (P<.001 for trend). However, mortality increased with increasing age but showed a decreasing trend over time among those aged 85 years or older from 24.2% (95% CI, 19.7%–28.7%) in 1993–1996 to 19.1% (95% CI, 16.4%–21.7%) in 2005–2009 and to 20.1% (95% CI, 17.0%–23.2%) in 2010–2012 (P = .003) (Table 4).

Discussion

We assessed national trends in incidence, etiology, surgical procedures performed, and mortality during inpatient admission for acute traumatic spinal cord injury in the United States from 1993 to 2012. Our data show that the overall absolute number of cases of acute traumatic spinal cord injury has modestly increased from 1993 to 2012, whereas the incidence rate has remained relatively stable (ie, 53 cases/million population in 1993 to 54 cases/million in 2012), with an estimated 13 706 cases in 1993 and an estimated 16 965 cases in 2012. There was a substantial increase in falls contributing to spinal cord injury incidence in those aged 65 to 84 years. There was substantial morbidity and mortality during acute inpatient hospital stays among patients with traumatic spinal cord injury. There were also increases in the proportion of cases undergoing procedures such as intervertebral disk excision and spinal canal decompression performed during inpatient acute spinal cord injury admissions.

Our findings on incidence rates of spinal cord injury are similar to findings from other studies. The Spinal Cord Injury Model Systems have for many years been the best source of data on the epidemiology of acute spinal cord injury.[1] An incidence rate of 40 per 1 million persons is based on regional estimates from the 1980s.[1] The most recent Model Systems estimate of 12 500 new cases per year was revised recently from 11 000 new cases per year based on the increase in the US population. A recent study based on the Nationwide Emergency Department Sample estimated the spinal cord injury incidence in 2007–2009 to be 56.4 per 1 million adults.[32] State registries from the 1980s have been discontinued.[33] Use of regional spinal cord injury incidence rates from the 1980s and extrapolation of those data to the current US population do not account for changes in seatbelt laws, vehicle safety, a rapidly increasing elderly population that is at a higher risk of falls, and advances in health care delivery that may lead to reduced motor vehicle crash mortality. In one of the first estimates of spinal cord injury incidence for 1970–1977,[3] Bracken et al reported an overall incidence of 40.1 per 1 million with a male-female ratio of 2.4:1.

Because the incidence and etiology of spinal cord injury vary by age, we reported overall incidence and age-stratified incidence rates from 1993 to 2012. The overall incidence rate of spinal cord injury in the male population aged 16 to 24 years (144 cases/million in 1993 and 87 cases/million in 2012) and aged 25 to 44 years (96 cases/million in 1993 and 71 cases/million in 2012) substantially declined over time. Public education, improved motor vehicle safety features, stricter safety belt laws, and drunk driving laws and their enforcement may have contributed to this overall decline in spinal cord injury rates in these age groups.[34] Price et al[10] used data from the state of Oklahoma and reported that incidence rates of spinal cord injury were highest in the male 20- to 24-year-old population (annual rate, 144 cases/million) followed by the male 15- to 19-year-old population (annual rate, 136 cases/million). Our study does not account for those who died at the scene of the injury or those who may have died in the emergency department. We also found that spinal cord injury incidence rate was the highest (in most of the years) in those aged 85 years or older but that the rates showed a small increase over time. Conversely, spinal cord injury incidence rates have substantially increased over time in the 65- to 74-year-old and 75- to 84-year-old age groups and now account for a larger proportion of total spinal cord injury cases because of the increasing elderly population.

There was also an increase in the proportion of spinal cord injuries resulting from falls among elderly people. This is a major public health issue and it likely represents a more active 65- to 84-year-old US population currently compared with the 1990s, which increases the risk of falls in this age group. This issue may be further compounded in the future because of the aging population in the United States. Although spinal cord injury resulting from firearm injuries remained relatively stable over the duration of our study, firearm injury is a major preventable contributor of spinal cord injury, especially in the 16- to 24-year-old age group, in whom the rate of spinal cord injury attributable to firearm injury was higher. Surkin et al[11] reported data from the state of Mississippi and found that vehicular causes followed by violence were the most common causes of spinal cord injury between 1992 and 1994.

The use of vena cava filters in acute spinal cord injury has also substantially increased from 1993–1996 to 2010–2012. This may represent the increased awareness of deep venus thrombosis as a serious complication and the increased use of retrievable vena cava filters since the early 2000s.[35] It may also represent improved *ICD-9-CM* coding of these procedures in the databases over time. Other procedures performed during acute inpatient spinal cord injury admissions, such as intervertebral disk excision and spinal canal decompression, also increased during the period of this study.

Our study has several limitations. First, spinal cord injury incidence may be underestimated because the NIS does not include acute spinal cord injury cases from federal facilities, although most patients with acute spinal cord injury are transferred to nonfederal facilities. Second, there may be errors in coding of acute traumatic spinal cord injury, although the NIS has been extensively validated and reported to perform well for many estimates.[19,20] The *ICD-9-CM* codes for patients with acute spinal cord injury vs patients with chronic spinal cord injury who are subsequently admitted to a hospital are different. It is possible that some patients were double counted or miscoded in the NIS, although there is no evidence to suggest that this coding bias was differential across the years of our study or between acute and chronic spinal cord injury. Third, the E codes for classification of falls has undergone some changes since October 1994.[22] Most of these changes (such as adding a new fourth digit to some of the *ICD-9-CM* codes for falls) were made to classify falls into expanded categories and likely do not affect our overall estimates of the percentage of patients with falls. Moreover, most of these changes occurred in 1995 and our study determined the etiology of spinal cord injury starting in 1997. Fourth, the NIS database does not include information on variables such as degree of neurologic deficits and clinical functional outcomes.

Conclusions

Between 1993 and 2012, the incidence rate of acute traumatic spinal cord injury remained relatively stable but, reflecting an increasing population, the total number of cases increased. The largest increase in the incidence of spinal cord injury was observed among older patients, largely associated with an increase in falls, and in-hospital mortality remained high, especially among elderly persons.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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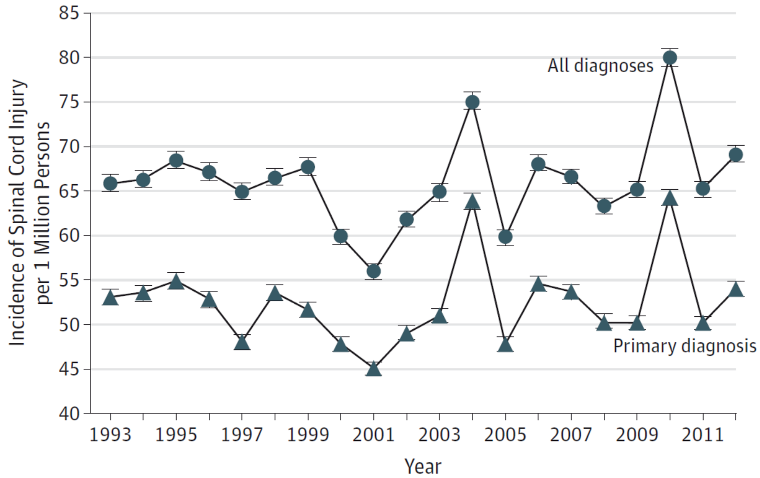
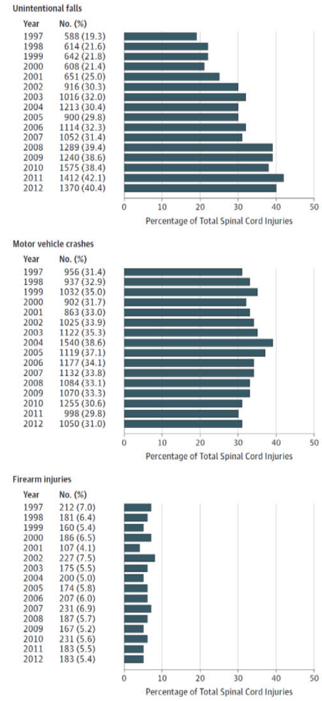


Primary diagnosis indicates primary spinal cord injury diagnosis or secondary spinal cord injury diagnosis with a primary trauma diagnosis. All diagnoses indicate any diagnosis code for spinal cord injury with or without a trauma code.

Figure 1.

Temporal Trends in Acute Traumatic Spinal Cord Injury Incidence Rate per 1 Million Persons in the United States, 1993–2012



Total numbers of spinal cord injury cases for each year differ slightly from those in Table 1 because the statistical software used in this figure excluded cases with any invalid *International Classification of Diseases, Ninth Revision, Clinical Modification* codes. Unweighted calculations are presented in this figure.

Figure 2.

Trends in Etiology of Acute Traumatic Spinal Cord Injury in the United States

Table 1

Number of Patients in Nationwide Inpatient Samples With Acute Traumatic Spinal Cord Injury in the United States, 1993–2012

	Spinal Cord Injury as Primary Diagnosis			Spinal Cord Injury as Any Diagnoses
Year	**No. of Patients**	**Age, Mean, y**	**Male, %**	**No. of Patients**
1993	2659	40.5	73.5	3279
1994	2680	40.5	75.5	3355
1995	3112	40.9	72.1	3895
1996	2983	42.0	73.2	3808
1997	3048	41.8	72.4	4094
1998	2848	42.5	73.2	3539
1999	2946	42.1	72.8	3867
2000	2849	43.3	74.7	3574
2001	2611	44.7	73.6	3248
2002	3025	44.8	72.8	3823
2003	3180	45.1	71.2	4050
2004	3993	44.2	71.3	4713
2005	3021	44.8	71.3	3770
2006	3453	46.3	72.5	4310
2007	3357	46.8	72.3	4180
2008	3274	48.8	70.0	4128
2009	3217	49.3	69.7	4183
2010	4106	48.6	71.1	5115
2011	3354	51.1	70.1	4373
2012	3393	50.5	70.7	4339

Table 2

Age- and Sex-Stratified Estimated Acute Traumatic Spinal Cord Injury Incidence Rates per 1 Million Persons in the United States

	Spinal Cord Injury Incidence Rate (95% CI) per Million					
Year	**Age 16–24 y**	**Age 25–44 y**	**Age 45–64 y**	**Age 65–74 y**	**Age 75–84 y**	**Age ≥85 y**
Male						
1993	144 (112–177)	96 (76–117)	76 (61–91)	84 (63–106)	104 (74–134)	204 (133–276)
1994	151 (118–184)	98 (75–120)	86 (70–102)	80 (61–100)	126 (94–158)	178 (119–238)
1995	140 (106–174)	99 (81–117)	75 (63–87)	81 (64–99)	129 (101–158)	200 (138–263)
1996	134 (102–167)	96 (76–115)	80 (66–94)	97 (76–117)	108 (81–135)	133 (71–194)
1997	117 (87–147)	87 (70–103)	71 (57–85)	78 (61–94)	108 (85–131)	154 (103–204)
1998	130 (102–157)	105 (83–126)	77 (60–95)	72 (56–89)	150 (120–180)	191 (127–254)
1999	121 (97–144)	90 (74–106)	81 (68–95)	83 (66–101)	127 (100–155)	221 (151–292)
2000	113 (93–134)	86 (70–101)	76 (64–89)	86 (69–103)	122 (97–146)	180 (128–232)
2001	102 (80–123)	75 (61–88)	71 (61–82)	88 (70–105)	150 (122–178)	196 (135–256)
2002	103 (81–126)	86 (69–102)	80 (69–94)	90 (73–106)	138 (111–164)	220 (165–275)
2003	105 (83–126)	81 (66–96)	89 (74–104)	91 (73–110)	131 (106–155)	220 (160–281)
2004	139 (108–169)	100 (80–120)	111 (90–133)	109 (85–132)	147 (115–180)	223 (160–286)
2005	101 (80–122)	73 (58–88)	78 (65–92)	87 (69–105)	122 (97–148)	192 (139–244)
2006	107 (86–127)	91 (75–107)	92 (78–105)	108 (89–127)	155 (127–183)	249 (192–307)
2007	111 (87–134)	83 (67–99)	92 (76–109)	104 (84–123)	151 (121–181)	244 (185–303)
2008	90 (71–109)	72 (58–86)	86 (71–100)	113 (93–133)	160 (128–191)	234 (172–296)
2009	88 (71–106)	66 (55–78)	90 (76–104)	119 (100–138)	158 (128–188)	218 (166–271)
2010	108 (86–129)	100 (82–119)	112 (94–131)	135 (110–160)	196 (161–232)	271 (206–336)
2011	81 (63–99)	67 (51–82)	89 (72–105)	122 (98–146)	179 (149–209)	238 (186–291)
2012	87 (75–99)	71 (62–79)	105 (94–117)	131 (113–149)	151 (127–176)	234 (183–285)
Female						
1993	42 (31–54)	26 (19–32)	27 (20–33)	32 (24–41)	65 (49–80)	107 (71–142)
1994	37 (27–48)	26 (20–32)	22 (17–28)	32 (24–41)	53 (40–66)	91 (61–121)
1995	34 (27–41)	31 (25–37)	25 (19–31)	51 (40–63)	84 (66–101)	78 (54–102)

	Spinal Cord Injury Incidence Rate (95% CI) per Million					
Year	**Age 16–24 y**	**Age 25–44 y**	**Age 45–64 y**	**Age 65–74 y**	**Age 75–84 y**	**Age ≥85 y**
1996	32 (25–40)	29 (23–34)	28 (22–33)	38 (28–49)	68 (53–83)	111 (83–139)
1997	32 (24,40)	24 (20–29)	21 (17–26)	44 (34–54)	64 (50–78)	86 (59–113)
1998	38 (28–48)	24 (19–29)	27 (22–32)	39 (30–47)	66 (52–81)	100 (72–128)
1999	38 (29–48)	23 (19–27)	25 (20–30)	32 (24–41)	63 (49–77)	87 (61–113)
2000	31 (22–39)	23 (18–28)	19 (14–23)	33 (25–42)	66 (53–79)	117 (87–147)
2001	26 (19–33)	18 (14–23)	22 (17–26)	36 (27–45)	80 (64–95)	72 (50–93)
2002	29 (22–36)	24 (19–28)	26 (20–32)	36 (27–45)	80 (64–96)	93 (68–118)
2003	33 (25–42)	25 (19–31)	27 (22–32)	49 (39–59)	77 (60–93)	101 (76–126)
2004	45 (33–58)	33 (25–41)	35 (27–42)	54 (37–71)	96 (79–113)	109 (80–137)
2005	30 (22–37)	22 (17–27)	23 (19–28)	40 (31–49)	84 (70–97)	110 (83–136)
2006	35 (27–44)	23 (18–27)	31 (25–36)	43 (34–52)	83 (68–98)	122 (94–151)
2007	32 (24–41)	22 (18–27)	28 (23–33)	46 (36–56)	97 (80–113)	111 (82–139)
2008	25 (17–32)	24 (18–30)	30 (24–35)	54 (43–65)	99 (81–117)	123 (94–152)
2009	25 (18–31)	20 (16–25)	30 (25–35)	60 (47–72)	99 (79–119)	121 (95–148)
2010	35 (26–44)	28 (22–35)	36 (30–42)	63 (51–75)	113 (92–133)	156 (126–187)
2011	21 (15–27)	20 (15–24)	30 (25–35)	55 (44–67)	100 (83–118)	151 (123–180)
2012	27 (21–33)	21 (17–24)	35 (30–39)	53 (44–62)	101 (84–118)	134 (109–159)

Table 3

Surgical Procedures Performed for Acute Traumatic Spinal Cord Injury in the United States[a]

Procedures	No. With Procedure (%) [95% CI]				
	1993–1996 (n=11 425)[b]	**1997–2000 (n=11 684)[b]**	**2001–2004 (n=12 796)[b]**	**2005–2009 (n=16 315)[b]**	**2010–2012 (n=10 849)[b]**
Intervertebral disk excision	1276 (11.2) [10.6–11.7]	1617 (13.8) [13.2–14.5]	1949 (15.2) [14.6–15.9]	2544 (15.6) [15.0–16.1]	1725 (15.9) [15.2–16.6]
Spinal canal decompression	1160 (10.2) [9.6–10.7]	1343 (11.5) [10.9–12.1]	1676 (13.1) [12.5–13.7]	2467 (15.1) [14.6–15.7]	1721 (15.9) [15.2–16.6]
Spinal fusion[c]				2019 (12.4) [11.9–12.9]	1601 (14.8) [14.1–15.4]
Vena cava filter	441 (3.9) [3.5–4.2]	745 (6.4) [5.9–6.8]	1134 (8.9) [8.4–9.4]	2359 (14.5) [13.9–15.0]	1192 (11.0) [10.4–11.6]

[a]Unweighted calculations are presented.

[b]Numbers of spinal cord injury cases are slightly different from those in Table 1 because statistical software used for this table excludes cases with any invalid *International Classification of Diseases, Ninth Revision, Clinical Modification* codes.

[c]Calculated only for 2005–2012 because effective for discharges after October 1, 2004, the Centers for Medicare & Medicaid Services added payments for new spinal fusion devices.

Table 4

Temporal Trends in Outcomes of Acute Traumatic Spinal Cord Injury in the United States[a]

Characteristics	Years 1993–1996	1997–2000	2001–2004	2005–2009	2010–2012	*P* Value for Armitage Trend
Mortality						
Age 16–24 y						.02
No. died/total	90/2402	74/2254	88/2280	121/2664	70/1475	
% (95% CI)	3.8 (3.0–4.5)	3.3 (2.5–4.0)	3.9 (3.1–4.7)	4.5 (3.8–5.3)	4.8 (3.7–5.8)	
Age 25–44 y						.05
No. died/total	172/4190	137/4101	149/3886	194/4393	121/2607	
% (95% CI)	4.1 (3.5–4.7)	3.3 (2.8–3.9)	3.8 (3.2–4.4)	4.4 (3.8–5.0)	4.6 (3.8–5.4)	
Age 45–64 y						.07
No. died/total	99/2160	128/2438	193/3225	282/4619	189/3428	
% (95% CI)	4.6 (3.7–5.5)	5.3 (4.4–6.1)	6.0 (5.2–6.8)	6.1 (5.4–6.8)	5.5 (4.7–6.3)	
Age 65–74 y						.01
No. died/total	120/970	112/949	140/1109	181/1680	130/1376	
% (95% CI)	12.4 (10.3–14.4)	11.8 (9.7–13.9)	12.6 (10.7–14.6)	10.8 (9.3–12.3)	9.5 (7.9–11.0)	
Age 75–84 y						.02
No. died/total	140/731	168/851	190/1072	259/1462	153/1001	
% (95% CI)	19.2 (16.3–22.0)	19.7 (17.1–22.4)	17.7 (15.4–20.0)	17.7 (15.8–19.7)	15.3 (13.1–17.5)	
Age ≥85 y						.003
No. died/total	84/347	109/424	143/494	160/840	129/643	
% (95% CI)	24.2 (19.7–28.7)	25.7 (21.5–29.9)	29.0 (24.9–32.9)	19.1 (16.4–21.7)	20.1 (17.0–23.2)	
Overall						<.001
No. died/total	749/11 414	760/11 677	940/12 646	1227/16 302	811/10 837	
% (95% CI)	6.6 (6.1–7.0)	6.5 (6.1–7.0)	7.4 (7.0–7.9)	7.5 (7.1–7.9)	7.5 (7.0–8.0)	
Length of acute stay, median (interquartile range), d	10 (4–20)	8 (3–16)	8 (4–16)	8 (4–16)	7 (4–15)	

[a]Unweighted calculations are presented. Excludes missing data (for mortality, n = 193 [0.31%]; for length of stay, n = 55 [0.09%]).