

Original Article

Work-related tetraplegia: cause of injury and annual medical costs

B Webster^{*1}, G Giunti², A Young¹, G Pransky¹ and S Nesathurai^{2,3,4,5}

¹Liberty Mutual Center for Disability Research, Liberty Mutual Research Institute for Safety, Hopkinton, MA, USA;

²Boston Medical Center, Department of Rehabilitation Medicine, Boston, MA, USA; ³School of Biomedical Sciences, University of Buffalo, Erie County Medical Center, Buffalo, NY, USA

Study design: Descriptive study.

Objective: To describe the demographics, cause of injury, and annual-paid medical costs for the 5 years following injury for cases of work-related tetraplegia.

Setting: A single United States workers' compensation (WC) claims database.

Methods: Tetraplegia cases with initial date of injury from 1 January 1989 to 31 December 1999 were selected by cross-referencing word search terms pertaining to body part injured and nature of injury. The main outcome measures were injury causes and annual-paid medical payments (adjusted to year 2000 medical consumer price index) of work-related tetraplegia by injury group for each year postinjury over a 5-year time period.

Results: A total of 62 claimants with work-related tetraplegia injured between 1 January 1989 and 31 December 1999. The vast majority of those identified were male claimants (92%) and more than a quarter worked in the construction industry (26%). Other highly represented industries included transportation and retail (15% each), manufacturing (13%), and agriculture and utility (11% each). The majority of injuries were the result of falls (36%) and vehicular accidents (34%). The mean Year 1 cost was \$560 524 for those with a high-level tetraplegia (C2–4 ASIA A–C), \$431 033 for a low-level injury (C5–8 ASIA A–C), and \$178 041 for those with an ASIA D tetraplegia injury. The mean cost of subsequent years (Years 2–5) was \$130 992 for a high-level, \$129 250 for a low-level, and \$34 352 for an ASIA D tetraplegia injury.

Conclusions: Mean costs for Year 1 postinjury in WC cases are similar to previously published estimates. Comparing the current results with those of previous spinal cord injury cost studies suggests that those with work-related tetraplegia may receive more injury-related paid medical benefits after the first year postinjury than cases who do not receive WC-supported benefits.

Sponsorship: Supported, in part, by a grant from the National Institute on Disability and Rehabilitation Research (NIDRR) (Grant # H133N00024).

Spinal Cord (2004) 42, 240–247. doi:10.1038/sj.sc.3101526

Keywords: tetraplegia; cost; workers' compensation

Introduction

The annual incidence of traumatic spinal cord injury (SCI) in the United States (US) is approximately four per 100 000 population resulting in 11 000 new cases per year, with an estimated prevalence of 183 000–230 000 persons.¹ Tetraplegia cases represent over 50% of SCIs,

and are the most costly due to their substantial need for acute and long-term medical care, rehabilitation services, and disability-related resources.¹ The lifetime healthcare and living costs for a person sustaining a tetraplegic injury at age 25 have been estimated by the National Spinal Cord Injury Statistical Center to range from approximately \$1.2 million for low-tetraplegia cases (C5–8 ASIA A–C) to \$2.2 million for high-tetraplegia cases (C1–4 ASIA A–C).¹

In response to concerns regarding the significant economic impact of SCI, studies have attempted to describe and quantify the associated medical expenditures.^{2–10} Analyses for these studies relied upon either Model SCI Care Systems (federally funded centers for the care of SCI patients) data as recorded in the

*Correspondence: B Webster, Liberty Mutual Center for Disability Research, Liberty Mutual Research Institute for Safety, 71 Franklin Road, Hopkinton, MA 01748, USA

⁴Address when study was initiated: Boston Medical Center, Department of Rehabilitation Medicine, Preston Family Bldg., 732 Harrison Ave., Boston, MA 02118-2392, USA

⁵Current address: School of Biomedical Sciences, University of Buffalo, G219, Erie County, Medical Center, 462 Grider St., Buffalo, NY 14214, USA

National SCI Database (NSCID),²⁻⁵ state- or region-specific population data,⁶⁻⁸ or self-reported data based on a national sample of patients.⁹

Although providing substantial insight into the costs associated with SCI, prior studies have been limited by the incomplete capture of all related costs, the reliance on the self-report or estimation of expenditures, the extrapolation of costs for missing services, or estimations based on charges instead of actual payments. These limitations suggest that the published estimates may not reflect the actual medical costs paid by insurers.

In the workplace, traumatic injuries to the spinal cord represent less than one out of every 10 000 injuries.¹¹ However, the costs for these injuries are among the highest in the workers' compensation (WC) system. Estimates of the costs of work-related SCI are sparse, with only one study identified in a review of the literature.¹⁰ This study reported on the first postaccident year costs (including hospitalization, rehabilitation, and home-care costs) for SCI cases injured between 1950 and 1974 who were insured by two WC insurers.¹⁰

When WC insurance is the first payor for a work-related SCI, all medical and rehabilitation charges are forwarded to the WC insurer. This continues even if a person with work-related SCI qualifies for Social Security and Medicare insurance. Thus, WC databases have the advantage of being able to capture complete documentation of injury-related medical expenditures. In WC, payment begins on the date of injury and is comprehensive for acute and rehabilitation hospitalizations and readmissions, physician and therapy services, medications and supplies, durable equipment, transportation, environmental modifications, attendant care, and vocational rehabilitation, among other injury-related expenses.

The objective of this study was to: (1) describe the causes and industries represented by work-related tetraplegia SCI and (2) to describe the annual medical costs for 5 years postinjury for persons with tetraplegia covered by WC, and to compare expenditures among motor levels of injury. The decision was made to focus on tetraplegia rather than all types of SCI because evidence suggests that there is greater difference in coverage of care for tetraplegia cases under WC relative to non-WC insurance.¹²

Methods

Case selection and classification

The sample was obtained from a compensation insurer data source that covers approximately 8–10% of the US private WC market. Cases were selected with injury dates between 1 January 1989 and 31 December 1999. Lacking ICD.9 codes (International Classification of Diseases, 9th Revision), cases were first selected by cross-referencing National Commission of Compensation Insurance (NCCI) codes specific to: body part injured (multiple neck injury, vertebra, and spinal cord)

and injury type (contusion, crushing, dislocation, and fracture) with relevant word search terms in the accident description (paralysis, quadriplegia, etc). A partial list of known SCI claims was made available for comparison from the company's Catastrophic Claims Unit and no additional claims were found. Each computerized claim file containing demographic, accident, medical, and disability information was then manually reviewed to assure the accuracy of the tetraplegia diagnosis. One case with a concurrent traumatic brain injury (TBI) was excluded due to the effect the high costs associated with the TBI would have on the total cost of the case.

The motor level of injury was classified according to the revised 2000 International Standards for Neurological Classification of Spinal Cord Injury from the American Spinal Injury Association (ASIA).¹³ In order to do this classification, detailed medical and physical examination data from the computerized claim file corresponding to the end of the first year postinjury were evaluated by a resident physician in Physical Medicine and Rehabilitation, also a member of the research team (GG). When necessary, case managers were contacted to verify the motor level.

Ascertainment of payment data

Data specific to all medical expenditures including payment amount, service type, service date, provider name and type, and Physician's Current Procedural Terminology (CPT) codes¹⁴ were available from the WC data source from 1 January 1993 to 31 December 2000 and was extracted in March 2001. All expenditures were adjusted using the Year 2000 medical care component of the Consumer Price Index.¹⁵ Cost data were stratified according to the year postinjury when the service occurred for up to 5 years depending on the initial date of injury (ie, Years 1, 2, 3, 4, 5 postinjury). Although expenditures are described over the 5 years postinjury, data specific to medical services were only available from 1993 onwards. Consequently, cases with an initial injury date from 1989 to 1992 included only payment data from 1993 onwards (eg, postinjury Year 5 payment data were available for 1989 cases, postinjury Years 4 and 5 payment data were available for 1990 cases, etc). This resulted in an unequal total number and distribution of cases by year postinjury and by injury level (see Table 1).

Total annual expenditures for all WC injury-related medical services included payments for: the initial hospitalization and acute rehabilitation (applicable to Year 1 postinjury only), all subsequent hospital and rehabilitation readmissions related to SCI, outpatient services (ie, physician and therapy visits, diagnostic services), medications and medical supplies, durable medical equipment (including vehicle and home modifications), personal care attendants (including nursing services and nursing home care), ambulance/assisted transportation, and vocational rehabilitation services.

Table 1 Descriptive statistics describing medical costs incurred by level of injury for the first 5 years postinjury

Injury level	n	Medical costs incurred (Y2K adjusted in thousands)			
		Mean	Median	Minimum	Maximum
<i>C2-4 ASIA A-C</i>					
Year 1	5	587	585	517	692
Year 2	4	164	141	115	256
Year 3	4	116	116	87	144
Year 4	4	158	156	80	242
Year 5	5	113	98	49	180
<i>C5 ASIA A-C</i>					
Year 1	9	437	422	232	718
Year 2	6	160	150	38	295
Year 3	4	78	80	60	94
Year 4	4	100	78	52	194
Year 5	5	121	103	48	198
<i>C6 ASIA A-C</i>					
Year 1	10	461	454	281	669
Year 2	10	201	157	30	544
Year 3	8	147	155	52	224
Year 4	7	109	76	52	251
Year 5	8	141	92	45	323
<i>C7-C8 ASIA A-C</i>					
Year 1	2	257	257	249	265
Year 2	4	110	107	80	146
Year 3	6	89	76	45	172
Year 4	7	88	85	7	173
Year 5	7	93	92	23	148
<i>Central cord</i>					
Year 1	4	163	145	114	249
Year 2	4	37	38	0.8	70
Year 3	4	32	32	3	61
Year 4	5	38	27	0.9	105
Year 5	5	33	26	2	98
<i>ASIA D</i>					
Year 1	5	190	182	111	289
Year 2	6	29	21	3	65
Year 3	5	25	11	2	55
Year 4	3	5	5	0.9	9
Year 5	3	44	5	2	128

Analysis

Basic descriptive statistics were performed to describe the causes of injury and the costs incurred (see Tables 1 and 2). In order to facilitate comparisons with published research, injuries were classified according to the system employed by NSCID. This involves placing people into one of three injury categories: high tetraplegia, which includes all those with an injury to cervical spinal cord levels two to four and an ASIA grade of A, B, or C (C2-4 ASIA A-C); low tetraplegia, which includes all those with injuries to cervical spinal cord levels five to eight with an ASIA grade of A, B, or C (C5-8 ASIA A-C), and ASIA D, which includes all those with an ASIA grade of D and Central Cord Syndrome.

To facilitate the use of the results by those wanting to estimate the cost of work-related SCI, calculations were made of the mean (with 95% confidence intervals) cost of the various types of injury. The first run of this analysis revealed five outliers with costs at least 1.5 times the interquartile range above the third quartile. There were no low-end outliers. As outliers exert too much influence on the results,¹⁶ the decision was made to remove these data points from the analysis (information regarding these cases are presented in Table 4). This resulted in 158 data points being used in the final analysis.

ANOVA was also conducted to determine if there were significant differences between the costs incurred over the 5-year period between the three injury types. As no statistically significant within-injury category difference was found between Year 2 and 5 postinjury ($P > 0.05$), costs incurred were averaged and the term 'subsequent years' has been used to refer to the cost of injury in years following the Year 1 postinjury. In addition, ANOVA was used to determine if there were significant differences in costs associated with the various injury categories. This was undertaken for the first year postinjury as well as for the subsequent years.

This study was approved by the Institutional Review Committee (for the protection of human subjects) of the Liberty Mutual Research Institute for Safety.

Results

A total of 62 cases met the selection criteria. The cases were from 28 states. The geographic distribution of the cases, based on US Census Bureau geographic regions, was highest in the South (32 cases), followed by the Northeast (10 cases), the Midwest (10 cases), and the West (seven cases).¹⁷ There were 29 complete and 33 incomplete tetraplegia cases; with the C5 level ($n = 11$) being the most common level of complete cases and the C6 level ($n = 11$) being the most common level of incomplete cases (see Table 3). The subjects had an average age of 38.7 years (range 17-77) and the vast majority were male (92%). No cases were ventilator dependent, although this was not by design.

Industry groups and cause of injury

More than a quarter of the cases worked in the construction industry (26%), followed by transportation and retail (15% each), manufacturing (13%), agriculture and utility (11% each), and service (10%). The majority of injuries were the result of falls (36%), followed by vehicular accidents (34%). For further details regarding the causes of injury, including a comparison with other studies, refer to Table 2.

Medical costs of SCI

Details regarding the cost of medical care for each of the individual injury categories are presented in Table 1. The mean, 95% confidence intervals (CI), median,

Table 2 Causes of SCI by insurance benefits coverage

Cause	Workers' compensation (WC)		Non-WC ^a	All payors ^b	
	Current 1989–1999 N = 62	Rosenberg <i>et al</i> ¹⁸ 1986–1991 N = 74		Rosenberg <i>et al</i> ¹⁸ 1986–1991 N = 492	Price <i>et al</i> ⁶ 1988–1990 N = 376
Fall	35.5%	50.0%	15.9%	19.9%	20.3%
Vehicular accident	33.9%	18.9%	59.3%	47.8%	35.9%
Struck by/against	21.0%	18.9%	1.0%	4.3%	c
Violence	3.2%	5.4%	8.7%	11.2%	29.5%
Sports	3.2%	1.4%	10.6%	12.8%	7.3%
Other	3.2%	5.4%	4.4%	1.6%	7.0%

^aInformation relates to the population insured by payers other than workers' compensation

^bInformation relates to the entire population with no distinction between workers' compensation and non-workers' compensation insurance coverage

^cStruck by a falling object is included in the 'other cause of injury' category when reported to the NSCID and typically accounts for about 3% of new injuries

Table 3 Distribution of cases by level and completeness

Level	Complete	Incomplete
C2–4	7	1
C5	11	3
C6	8	11
C7	2	8
C8	1	3
Central	0	7
Total	29	33

minimum, and maximum (with outliers removed) for each injury category for Year 1 and subsequent years are displayed in Table 4. Details regarding the participants with out-of-the-ordinary costs (ie outliers) are provided in Table 5.

Comparisons of injury cost by category revealed statistically significant differences. Mean annual cost was higher in Year 1 than all other postinjury years, for all levels of injury. When the major injury categories were compared (outliers removed), the mean Year 1 costs for high-tetraplegia and low-tetraplegia cases were not found to be significantly different from one another. However, both were significantly higher than the mean Year 1 costs for ASIA D cases ($P < 0.05$). For further details, refer to Table 3. In relation to subsequent years, it was found that the ASIA D mean costs were significantly lower ($P < 0.05$) than the costs of high-tetraplegia and low-tetraplegia cases; however, the costs of high-tetraplegia cases were not significantly different from low-tetraplegia cases (see Table 4). Mean costs were significantly higher in Year 1 than in subsequent years for all injury categories.

Discussion

The current study provides information regarding work-related tetraplegic injuries. Results detail the demo-

graphics of those affected, the industries represented, how such injuries occur, and the annual medical costs of these injuries to the WC system.

Demographics

Gender In the current study, male subjects made up a higher proportion of those injured (92%) than has been reported in previous studies that included all levels of SCI and all insurance types (figures range from 80 to 85%).^{3,4,6} A study by Rosenberg *et al*¹⁸ compared patients receiving WC benefits (13.1% of the total sample) with those SCI cases receiving non-WC benefits from Colorado. They reported similar gender results to the current study for WC-covered SCIs (95%), but only 74% in the non-WC-covered sample were male subjects. The percentage of male subjects in the current study population is higher than the percentage of male workers in the US civilian labor force (54%)¹⁹ and is higher than the percentage of males who sustained lost-worktime injuries (66%) as reported by the Bureau of Labor Statistics.²⁰ The higher percentage of males sustaining tetraplegia may be the result of a higher percentage of male employees in industries such as construction (90.3%)²¹ and transportation (91.3%), which have a higher risk for serious accidents.²²

Age The WC- and Colorado WC-covered population in the Rosenberg *et al*¹⁸ study were slightly older (both with a mean age of 39 years) than the cases reported by the NSCID¹ and the non-WC-covered Colorado sample (mean ages of 35 and 34 years, respectively). The Rosenberg *et al* study suggested that the lower mean age in the non-WC-covered population was because 19% of the sample were students.

Cause of injuries More than a third of the WC-covered injuries in the current study and half of the WC cases in the Rosenberg *et al* study¹⁸ were the result of falls as compared to 16% in the non-WC-covered group in the Rosenberg *et al* study and 20% in the DeVivo *et al*⁴

Table 4 Year 1 and subsequent years postinjury costs by injury category (outliers removed)

	<i>Medical costs incurred (Y2 K adjusted in thousands)</i>			
	<i>Year 1</i>			<i>F</i>
	<i>High-tetraplegia (n=4)</i>	<i>Low-tetraplegia (n=21)</i>	<i>ASIA D (n=9)</i>	
Mean cost	561	431	178	20.035*
95% confidence interval	508–613	367–495	131–225	
Median	569	386	167	
Minimum	517	232	111	
Maximum	588	718	289	
	<i>Average of subsequent years</i>			<i>F</i>
	<i>High-tetraplegia (Observations = 17)^a</i>	<i>Low-tetraplegia (Observations = 73)^a</i>	<i>ASIA D (Observations = 34)^a</i>	
Mean cost	131	129	34	10.998*
95% confidence interval	91–171	102–156	14–55	
Median	134	104	28	
Minimum	49	6	2	
Maximum	180	329	128	

**P* < 0.001

^aObservations = number of data points available for analysis

Note: No first year cost information was available for C8 ASIA A–C cases. High-tetraplegia (C2–4 ASIA A–C), low-tetraplegia (C5–8 ASIA A–C), ASIA D (all levels with an ASIA grade of D and Central Cord Syndrome)

Table 5 Service category representing costs far in excess of the average

<i>Case</i>	<i>Year postinjury</i>	<i>Service category</i>
C4 ASIA A	Year 1	Durable medical equipment
C6 ASIA C	Year 2	Durable medical equipment and rehabilitation
C6 ASIA A	Year 4	Attendant care
C6 ASIA A	Year 5	Readmission and attendant care
Central cord syndrome	Year 4	Attendant care

study using the NSCID population that included 8.9–10.7% (depending on year postinjury) WC-covered patients. Fewer injuries in the WC-covered group were due to violence (3% in the current study and 5% in the Rosenberg *et al* study) as compared to the Rosenberg *et al* non-WC-covered group (9%) and the NSCID population (30%) (see Table 3).

In a population study of Oklahoma residents with SCI, Price *et al*⁶ found a similar percentage of injuries caused by falls to that reported in NSCID-based studies.^{1,2,5} However, Price *et al* reported a higher percentage of injuries caused by vehicular (48%) and sports-related (13%) accidents, and a lower percentage due to violence (11%). No information was given by Price *et al* regarding insurance coverage. The differences in the studies from Colorado¹⁸ and Oklahoma⁶ may reflect geographic variation.

It should be noted that prior studies included SCI at all levels, which may in part explain the difference in cause of injury distribution for the WC-covered sample as compared with the NSCID-based samples.^{1,2,5} This

suggestion is supported by the findings of Rosenberg *et al*,¹⁸ who found a higher proportion of lumbar and fewer cervical injuries in their WC-covered group. They suggested that this was the result of fewer vehicular accidents and, therefore, fewer cervical injuries and more falls producing more lumbar injuries. Another source of differing cause distribution may be that sports- and violence-related injuries are less likely to occur in the course of work and, therefore, would not be covered by WC.

Annual costs

Prior studies that described the costs of medical care for SCI cases have been derived from a variety of different population sources.^{3–10} The largest of the studies included information from patients in the Model SCI Care Systems obtained from the NSCID and included only those patients who consented to participate in the database. The NSCID captures information on an estimated 13% of new SCI cases in the US. Currently, information on SCI cases comes from 24 federally funded SCI care centers in the Model SCI Care System.^{1–4} Studies utilizing data from the NSCID have not reported on cost by injury level (ie, tetraplegia versus paraplegia). Another national sample of SCI patients reported by Harvey *et al*⁹ included patients from several sources including lists of organizations representing the disabled population, from independent living centers, and from names provided by other interviewed SCI persons.

Other studies have used sources of data from either state- or region-specific SCI populations. Menter *et al*⁸ surveyed patients from only one NSC center in Colorado. The study by Price *et al*⁶ of Oklahoma SCI patients

Table 6 Comparison of mean year 1 and subsequent years medical costs

Injury group	Medical costs incurred (Year 2000 adjusted in thousands)					
	1st Year			Subsequent years		
	Current	Johnson <i>et al</i> ⁷	NSCID ¹	Current ^a	Johnson <i>et al</i> ^{7,b}	NSCID ¹
High tetraplegia	561	510	572	131	186	102
Low tetraplegia	431	472	370	130	97	42
ASIA D ^c	178	83	169	30	3	12

^aMean costs incurred in Years 2–5

^bCost in Year 2 only

^cC5–8 ASIA D and central cord syndrome in the current study, ASIA D at any level for NSCID study, and Frankel D and E at any level for the Johnson *et al* study

reported on all 1989 SCI cases and a combined total for tetraplegics. Johnson *et al*⁷ reported on tetraplegic SCI cases included in a Colorado surveillance system in 1989.

Although 5.3–14.8% of cases (depending on the year of study) contained in the Model SCI Care System database are covered by WC insurance, the medical costs for these cases have not been reported separately.^{2–6} Nor have cost information specific to cases covered by WC insurance been reported in the other population studies.

Past studies reporting on the cost of SCI have utilized several different methodologies. In the NSCID-based studies, costs reported were either actual charges (as opposed to payments)^{3,4} or were derived from medical service histories obtained by telephone interviews and diaries kept by SCI patients and verified by providers or third-party payors.^{4,8}

The study by Price *et al*⁶ reported on charges, with extrapolation of these charges required for missing data. Charges were not available for physician/surgeon services, emergency transportation, outpatient rehabilitation, and subsequent admissions.

In the Johnson *et al*⁷ study, provider information was first obtained from patient interviews and hospital medical records. Medical charges were then drawn from billing information obtained from the providers. Costs were determined either from direct billing charges, by estimation of costs for identical services, or estimation of costs for similar services. For acute hospitalization costs, 95.8% of costs were captured by direct billing information, but for costs beyond the initial hospitalization, only 44.9% were captured by direct billing information. Because of this, the reported costs could be either an underestimate or overestimate due to participant recall or problems regarding services and providers.

Persons in the Harvey *et al*⁹ study completed a survey that required them to recall the quantity of services and items used. Lacking accurate information on SCI-related expenditures, the authors then priced these quantities using 1988 market prices. Recurring annual costs were reported for medical care beyond the period of recovery and rehabilitation time of injury (ie, 2 years postinjury or beyond).

The current study advances on previous studies as it includes a broader range of care settings and wider variety of care systems. The method used in the current study provides cost information for tetraplegia based on extensively documented actual payments made by a single WC insurer responsible for all injury-related expenditures. Owing to the complete documentation of actual payments, extrapolation of costs (as in prior studies) was not required. As a result, the study provides a more complete understanding of costs incurred by WC insurers. In addition, with the WC insurer responsible for all injury-related expenditures, WC claimants would be less likely to incur their own out-of-pocket expenses as compared with cases with other types of insurance coverage.

A comparison of the current study's mean medical costs for the Year 1 postinjury and the subsequent years with two other studies that reported costs for comparable injury groups using the various methods is presented in Table 6 (all costs adjusted to Year 2000 medical care component of the Consumer Price Index).^{1,7}

The estimates for Year 1 costs by Johnson *et al*⁷ compare well to the current study for the high- and low-tetraplegia groups, and fall within the 95% CI. However, the Year 1 mean costs for the ASIA D group (including Frankel D and E cases at any level) in the Johnson *et al* study were very different, with a mean cost less than half of that reported by the NSCID and by the current study. This large difference is likely to be attributable to both their inclusion of Frankel E cases (ie, no paralysis) with the Frankel D cases and to the fact that more than half of those in their study received no in-patient rehabilitation services. In contrast, the acute in-patient rehabilitation mean costs in the current study for ASIA D (cervical level only) cases accounted for 44% of the total Year 1 mean costs.

The subsequent year mean cost reported by Johnson *et al*⁷ (that included costs for Year 2 postinjury only) was well above the upper bound 95% CI for the current study's combined subsequent year mean cost in the high-tetraplegia group in the current study. Their subsequent year mean cost (\$97 155) was slightly below the lower bound 95% CI for the current study's combined subsequent year mean cost (\$102 883–

156 227) for the low-tetraplegia group. The higher costs for the high-tetraplegia group in subsequent years reported by Johnson *et al* may be associated with ventilator-dependent patients who were not represented in the current study's population. The lower mean cost for those in the low-tetraplegia group in subsequent years in the Johnson *et al* study may be related to their failure to capture all costs.

NSCID estimates for Year 1 costs for all three injury groups, and subsequent year costs for the high-tetraplegia group compare well to the current study's WC data, falling within the 95% CI.¹ However, the mean NSCID cost for subsequent years for the low-tetraplegia group was well below that observed in the current study. These differences may be related to the different follow-up period of the two studies. The NSCID study of postinjury charges beyond the first year postinjury was based on a population of randomly selected patients enrolled in the NSCID treated since 1973. A 1-year cross-section of data was collected prospectively through telephone interviews and diaries between 1989 and 1990.² As a result, most of the patients in the study were far beyond the initial 5 year postinjury period of the current study. Their medical condition and need for medical services would likely have stabilized as compared to the more acutely involved cases in the Johnson *et al*⁷ and the current study. In addition, due to advances in medical technology, medical treatments are likely to have changed over the past 10 years. Adjustment to the 2000 medical care component of the Consumer Price Index is unlikely to completely account for the costs associated with these advances.

Tate *et al*,¹² in 1994, documented differences in insurance benefits between Medicaid, third-party private insurers, and catastrophic payers (eg, WC and automobile no fault insurance) for tetraplegia, paraplegia, and ASIA D SCI. They found that persons with catastrophic insurance received significantly ($P < 0.05$) more benefits, particularly for accessible housing. Further, Tate *et al* evaluated postdischarge differences between payers 2 years after the initial SCI, and found that benefits for housing, transportation, personal-care assistance, equipment, and outpatient services were higher for persons with catastrophic insurance compared to Medicaid ($P < 0.05$) and third-party private payors ($P < 0.06$).²³ Differences between NSCID results and the current study findings for subsequent year costs may be related to differences between WC and other payors for the amount and type of attendant care provider (eg, nurse versus aide). Persons with WC coverage are likely to have skilled attendant care provided. In comparison, persons in the NSCID may not have had such coverage, requiring care be provided by a family member.

Limitations

A limitation associated with this study was the small sample size. In several instances, there were only a few

cases in each of the injury types. While there was a trend for the lower-level injuries to be less expensive than higher-level ones, few significant differences were found. In order to gain more precise estimates of the cost of the various types of SCI, further study with a larger sample size would be necessary.

Related to the problem of small sample size is the issue of those cases with costs well beyond what is typically incurred. In total, 163 data points relating to the various postinjury years were available for interpretation. In 3% of these, the cost was sufficiently extreme so as to be defined as an outlier. Although inspection of each of these cases revealed a possible explanation for why their costs were out of the ordinary, this does raise problems for those attempting to use the current information to estimate the likely costs of individual cases. Interpretation of study findings should be made with the understanding that there are likely to be cases that will prove to be more expensive than current estimates.

While the focus of this study was to describe the medical payments associated with work-related SCI, this should not be inferred to suggest that these are the highest or most significant of the costs incurred. DeVivo *et al*² provided an extensive discussion regarding indirect costs and Berkowitz *et al*²⁴ estimated that 65% of the direct and indirect cost of SCI was associated with lost wages and productivity. Additional indirect costs that are more difficult to quantify are those of pain and suffering experienced by the injured person and their families. With this in mind, further investigations of the wider costs of work-related SCI are warranted.

Summary and conclusion

Utilizing a centralized data source that was continuous and comprehensive for all actual insured expenditures, this study uniquely documented the demographics and annual medical costs of work-related tetraplegia. Results indicate that the vast majority of the current study's WC population were male and more than a quarter of the sample worked in the construction industry. The majority of work-related injuries were the result of falls and vehicular accidents. Overall, the current figures for the first year postinjury are comparable to the best previous published estimates of the medical costs for SCI. WC high-level tetraplegia group costs are also similar to other estimates in subsequent years. However, despite the absence of medical evidence of significant comorbidity in the case of lower-level tetraplegia and ASIA D cases, the subsequent year costs were substantially higher in the current study. Although there was no significant difference between those with high-level versus low-level tetraplegia, the conclusion can be drawn that ASIA D injuries cost significantly less than injuries of ASIA types A–C. Comparing the current results with those of previous studies of the cost of SCI suggests that those with work-related tetraplegia receive a higher level of reimbursement for postacute services than those with other insurance coverage.

Further research is necessary to determine if this has an effect on outcomes.

Acknowledgements

We acknowledge Jamil Ahmed, Radha Vijayakumar, Ashar Ata, and Santosh Verma for their assistance in data collection. We also acknowledge Russell Hensel for his technical assistance, and Helen Wellman, Rammahon Maikala, and Jon Mukand for their review of the manuscript.

References

- 1 National Spinal Cord Injury Statistical Center. Spinal cord injury: facts and figures at a glance. *J Spin Cord Med* 2001; **24**: 212–213.
- 2 DeVivo MJ, Whiteneck GG, Charles ED. The economic impact of spinal cord injury. In: Stover SL, DeLisa JA, Whiteneck GG (eds). *Spinal Cord Injury: Clinical Outcomes from the Model Systems*. Aspen Publishers: Gaithersburg, MD 1995, pp 234–271.
- 3 Cifu DX, Seel RT, Kreutzer JS, McKinley WO. A multicenter investigation of age-related differences in lengths of stay, hospitalization charges, and outcomes for a matched tetraplegia sample. *Arch Phys Med Rehabil* 1999; **80**: 733–740.
- 4 DeVivo MJ et al. Trends in spinal cord injury demographics and treatment outcomes between 1973 and 1986. *Arch Phys Med Rehabil* 1992; **73**: 424–430.
- 5 DeVivo MJ. Causes and costs of spinal cord injury in the United States. *Spinal Cord* 1997; **35**: 809–813.
- 6 Price C, Makintubee S, Herndon W, Istre GR. Epidemiology of traumatic spinal cord injury and acute hospitalization and rehabilitation charges for spinal cord injuries in Oklahoma, 1988–1990. *Am J Epidemiol* 1994; **139**: 37–47.
- 7 Johnson RL, Brooks CA, Whiteneck GG. Cost of spinal cord injury in a population-based registry. *Spinal Cord* 1996; **34**: 470–480.
- 8 Menter RR et al. Impairment, disability, handicap and medical expenses of persons aging with spinal cord injury. *Paraplegia* 1991; **29**: 613–619.
- 9 Harvey C et al. New estimates of the direct costs of traumatic spinal cord injuries: results of a nationwide survey. *Paraplegia* 1992; **30**: 834–850.
- 10 Webb SB, Berzins E, Wingardner TS, Lorenzi ME. First year hospitalization costs for the spinal cord injured patient. *Paraplegia* 1977–1978; **15**: 311–318.
- 11 US Department of Labor, Bureau of Labor Statistics. *Lost-Worktime Injuries: Characteristics and Resulting Time Away from Work, 2000* (USDLO2-196). [http://stats.bls.gov/oshome.htm, Series Id: CDU00013X3N] Washington, DC: US Government Printing Office 2000.
- 12 Tate DG, Forchheimer M, Daugherty J, Maynard F. Determining differences in post discharge outcomes among catastrophically and noncatastrophically sponsored outpatients with spinal cord injury. *Am J Phys Med Rehabil* 1994; **73**: 89–97.
- 13 American Spinal Injury Association. *International Standards for Neurological Classification of SCI ASIA*. Chicago: American Spinal Injury Association 2000.
- 14 American Medical Association. *Physicians' Current Procedural Terminology. CPT 2001*. Chicago: American Medical Association 2000.
- 15 US Department of Labor, Bureau of Labor Statistics. Consumer Price Index – All Urban Consumers, US City Average, Medical Care, Series Id: CUUR0000SAM. Available from URL: <http://data.bls.gov/servlet/SurveyOutputServlet>.
- 16 Tabachnick B, Fidell L. *Using Multivariate Statistics*, 3rd edn. New York (NY): Harper Collins 1996.
- 17 US Census Bureau. Geographic Areas Reference Manual. <http://www.census.gov/geo/www/garm.html>.
- 18 Rosenberg NL, Gerhart K, Whiteneck G. Occupational spinal cord injury: demographic and etiologic differences from non-occupational injuries. *Neurology* 1993; **43**: 1385–1388.
- 19 Fullerton HN. Evaluating the 1995 labor projections. *Monthly Labor Rev* 1997; 5–9.
- 20 US Department of Labor, Bureau of Labor Statistics. *Lost-worktime Injuries and Illnesses: Characteristics and Resulting Time Away From Work, 2000*. [USDLO2-196] Washington, DC: US Government Printing Office 2002. Also available from URL: <http://stats.bls.gov/iif/oshwc/osh/case/osnr0015.pdf>.
- 21 US Department of Labor, Bureau of Labor Statistics. Labor Force Statistics from the Current Population Survey, Series Id: LFU11106000001 and LFU11106000000. Available from URL: <http://www.bls.gov/data/>.
- 22 US Department of Labor, Bureau of Labor Statistics. Labor Force Statistics from the Current Population Survey, Series Id: LFU1132015800001 and LFU1132015800000. Available from URL: <http://www.bls.gov/data/>.
- 23 Tate DG, Forchheimer M, Daugherty J, Maynard F. Insurance benefits coverage for persons with spinal cord injuries: determining differences across payers. *J Am Paraplegia Soc* 1993; **16**: 76–80.
- 24 Berkowitz M et al. *The Economic Consequences of Traumatic Spinal Cord Injury*. New York (NY): Demos Publications 1992.