Spinal Cord (2006) 44, 374–382

www.nature.com/sc

Original Article

Rehospitalization following compensable work-related tetraplegia

A Young*[,1], B Webster[1], G Giunti[2], G Pransky[1] and S Nesathurai[3]

[1]*Liberty Mutual Center for Disability Research, Liberty Mutual Research Institute for Safety, Hopkinton, MA, USA;* [2]*Medicine Rehabilitation Associates, Lewiston, ME, USA;* [3]*Department of Physical Medicine and Rehabilitation, Harvard Medical School, Spaulding Hospital, Boston, MA, USA*

Design: Descriptive study.
Objectives: To document the characteristics of rehospitalization following work-related tetraplegia, investigate risk factors for rehospitalization and identify opportunities for rehospitalization prevention.
Setting: Workers' compensation administrative database with national coverage.
Methods: The administrative database of a large workers' compensation provider was searched for work-related tetraplegia claims with dates of injury between 1 January 1989 and 31 December 1999. In all, 61 cases were identified where detailed rehospitalization information was available. Medical payment data were extracted, rehospitalization reasons were coded, and rates, costs and length of stay were calculated.
Results: In all, 62% of cases were rehospitalized at some time during the period for which data were available. The average number of days the study group spent rehospitalized per year was 9.2 and the average annual cost was $14 197. The most common reasons for rehospitalization were dermatological (23%), orthopedic (18%) and urological (14%). It was found that as many as 74% of the total number of days persons spent rehospitalized, 64% of the monies spent on rehospitalization, and 47% of rehospitalizations could have been prevented.
Conclusions: Consistent with earlier research, the ability to identify risk factors for rehospitalization was limited. However, the current study does highlight the extent to which rehospitalizations disrupt the lives of people with work-related tetraplegia and that a substantial proportion of rehospitalizations can be avoided.
Sponsorship: The research was supported, in part, by a grant from the National Institute on Disability and Rehabilitation Research National Model SCI Systems (Grant no. H133N00024).
Spinal Cord (2006) **44,** 374–382. doi:10.1038/sj.sc.3101858; published online 22 November 2005

Keywords: workers' compensation; injury; medical services; rehospitalization; readmission

Introduction

Research into health outcomes following spinal cord injury (SCI) has found that the resulting physiologic changes can increase lifelong susceptibility to secondary health problems.[1] These problems can be significant and can result in rehospitalization. Indeed, it has been found that following discharge for initial treatment, people with SCI are more likely to be hospitalized, and to stay in hospital for longer periods than are members of the general population.[1–3]

Frequent and prolonged admissions to hospital significantly affect the ability of people with SCI to function in the usual activities of life, including regular involvement in vocational activities and the maintenance of meaningful personal relationships.[2,4] Additionally, rehospitalizations are a significant cost to patients and society, with estimates from 1987 indicating that the median cost per rehospitalization was $9683.[5] Clearly, reducing the number and duration of rehospitalizations is an avenue for reducing the burden of SCI.

Research investigating rehospitalization following SCI has found that the reasons for rehospitalization are varied and most commonly include evaluation and care of urinary tract disorders, treatment of cardiorespiratory disease, neurological disorders, orthopedic problems and soft tissue care.[3–6] Although many rehospitalizations are unavoidable, indeed some result in an improvement in individuals' functional status, others have the potential to be avoided. Limiting these preventable readmissions holds the potential for reducing the burden of injury for those with SCI.

*Correspondence: AE Young, Center for Disability Research, Liberty Mutual Research Institute for Safety, 71 Frankland Road, Hopkinton, MA 01748, USA

This report details the frequency, costs, length of, and reasons for rehospitalizations following work-related tetraplegia and attempts to identify risk factors for rehospitalization. A particular focus of the study was to add to the understanding of potentially preventable rehospitalizations. Our primary goals were to (1) describe the occurrence of rehospitalization following work-related SCI and (2) identify opportunities for prevention. The current work builds upon our earlier investigations of work-related SCI[7,8] and extends upon prior studies by including detailed information on costs and length of stay.

Methods

Procedure

The sample was identified by searching a workers' compensation provider's administrative database for work-related tetraplegia claims with dates of injury occurring between 1 January 1989 and 31 December 1999. During this time, the provider insured 8–10% of all US private sector workers. Level of injury, as determined at the time of the first year follow-up visit, was classified according to the revised 2000 International Standards for Neurological Classification of Spinal Cord Injury from the American Spinal Injury Association (ASIA). Cases were grouped by injury category: High Tetraplegia (C2-4 ASIA A–C), Low Tetraplegia (C5-8 ASIA A–C) and ASIA D (any injury to the cervical spine with an ASIA D classification). Additional details regarding case identification and approach to data collection have been reported previously.[7]

The workers' compensation provider's centralized data source was continuous and comprehensive for all actual insured expenditures. Virtually all SCI-related care needs are covered under the workers' compensation insurance system and each service is identified as a single line item in the database. Information drawn from the data source included payment amount, service type, service date, provider name and type, and Physician's Current Procedural Terminology (CPT) codes. Line item payments were assigned to subcategories by expenditure years using available billing information. CPT codes were used when available to identify services. If CPT codes were lacking, billing codes of the insurer were used in combination with service provider description and designation codes. On certain occasions, it was necessary to review additional medical and disability information (including case and claim manager notes) to identify the type of service provided.

Information regarding expenditures for rehospitalization was extracted from the database. Expenditures included all payments for services associated with a rehospitalization, except for durable medical equipment, which was categorized separately, and were compiled from date of admission to date of discharge. All expenditures were adjusted using the Year 2000 medical care component of the Consumer Price Index.[9] Payment data were stratified by the year following injury when the service was provided, and are presented for up to 5 years after the initial date of injury (ie, Years 1, 2, 3, 4, 5 following injury, with each year equating to 365 days). Although expenditures are described over the 5 years following injury, continuous and reliable data specific to medical services were only available from 1993. Consequently, cases with an initial injury date from 1989 to 1992 included only payment data from 1993 forward. This resulted in the full 5 years of data not being available for all cases. Information was available for Year 1 in 35 cases, Year 2 in 33 cases, Year 3 in 30 cases, Year 4 in 29 cases, and Year 5 in 33 cases. The mean length of time for which data were available was 2.6 years.

Based on earlier findings that indicated little difference between postinjury Years 2 and 5,[7] and to facilitate comparisons with earlier studies, payments for years 2–5 were averaged and the term 'subsequent years' is used to refer to average annual post first-year payments. If information was not available for all 4 years, the mean was calculated using the number of years for which data were available. Exploratory analyses were conducted to determine overall and group means. Between-group differences were tested using ANOVA and *t*-tests. *Post-hoc* testing was conducted using Tukey's honestly significant difference or Tamhane's was used depending on equality of variance. Statistical significance was interpreted as $P<0.05$. χ^2 analysis was also employed when needed. All analyses were undertaken using SPSS. All procedures were approved by the Liberty Mutual Research Institute for Safety Institutional Review Committee.

The primary reason for each rehospitalization was classified into one of 11 broad categories. These were urology (mostly urinary tract infections), dermatology (decubiti), pain management, rehabilitation, neurology (eg, managing spasticity), orthopedics (eg, cervical fusion for stabilization, treatment of fractures and heterotrophic ossification), cardiorespiratory (predominantly pneumonia), gastrointestinal (mainly secondary to problems associated with bowel management), other infections, other reasons (not classifiable into other categories) and unknown (insufficient information available). In cases where dates of rehospitalization were contiguous (such as when an individual was transferred for rehabilitation following an orthopedic admission) the rehospitalization was classified as one event and categorized based on the reason for the initial rehospitalization (in the example above, the rehospitalization would be categorized as orthopedic).

To determine whether rehospitalizations were potentially preventable, the investigators, including an internist, physiatrist, physician assistant/physiotherapist, and a health psychologist, reviewed the case notes. Based on the method used by Davidoff,[5] rehospitalizations considered potentially preventable included those where the admitting diagnosis was most likely the result of inadequate patient compliance and/or problem solving. These included skin pressure sore, urinary tract infec-

tion, pulmonary infection, deep-venous thrombosis and burns. Nonpreventable rehospitalizations were mainly for surgical procedures to repair or overcome a problem that resulted from the injury such as removal of instrumentation, sphincterotomy, tendon transfer, or intrathecal Baclofen pump. Rehabilitation rehospitalizations were divided into two groups: (1) those patients admitted for training expected to lead to enhancement in functional capacity, and (2) those patients admitted because of a reduction in the ability to perform self-care or mobility that was not the result of new neurologic loss. Rehabilitation rehospitalizations in the first group were classified as nonpreventable; however, those in the second group were classified as preventable. If there was substantial doubt or dissension between study group members with regard to preventability, the rehospitalization was categorized as nonpreventable (*Note*: This only occurred in two cases).

The annual rate of rehospitalization was calculated by dividing the number of rehospitalizations by the number of years for which patient data were available. Similarly, the annual rate of preventable rehospitalization was calculated by dividing the number of preventable rehospitalizations by the number of years for which patient data were available.

Owing to the nature of the data recorded in the administrative database, the opportunity to test for risk factors was limited to age, gender and place of residence. To test the impact of place of residence, the United States Department of Agriculture (USDA) Economic Research Service (ERS) 2003 rural–urban continuum codes were used to classify workers' residencies as metropolitan or nonmetropolitan. An individual whose address was within a county with a continuum code of 1–3 was designated as living in a metropolitan area. Those living in other areas (ie, continuum codes 4–9) were classified as living in a nonmetropolitan area.

Subjects

The search of the database identified 61 eligible cases with useable data residing in 28 states. (*Note*: One additional case was identified; however, a lack of detailed readmission data resulted in the person being excluded from the analysis.) The average age at injury was 38.7 years and 92% of cases were male. A total of 8 persons had High Tetraplegia and 38 people had Low Tetraplegia. The remaining 15 people were classified as having an ASIA D impairment. The majority of injuries were the result of falls (36%), followed by vehicular accidents (34%), struck by/against (21%), violence and sports (3.2% each). For further demographic information, please consult our earlier publication.[7]

Results

In total, 120 rehospitalizations were identified. The average length of stay was 10.9 (SD 22.8) days, the minimum was 1 day, the maximum was 174 days and 46% of rehospitalizations were 7 days or longer. In all, 62% of study subjects were readmitted during the period for which data were available and multiple rehospitalizations were quite common – on average, 19.8% of cases were readmitted more than once a year.

In the first year of injury, 51% of the cases were readmitted. This percentage dropped in later years, with little difference observed in the rate of rehospitalization in Years 2–5: Year 2 = 39%, Year 3 = 40%, Year 4 = 28%, Year 5 = 36%. Rehospitalizations of a week or longer occurred in 38% of the cases for which first-year data were available, 28% of Year 2 cases, 48% of Year 3 cases, 59% of Year 4 cases and 52% of Year 5 cases. In all, rehospitalizations of a week or longer were experienced by 43% of the sample.

The average number of days the study group spent rehospitalized annually was 9.2 (SD 20.3); however, this mean was inflated by a number of extreme values (nine that were over 24 days). After the three most extreme values were excluded (5% top-end trim), the resulting mean was found to be 5.3 days (SD 9.8). Although the percentage of cases with rehospitalization was higher in Year 1, the average number of days spent hospitalized was not: Year 1 = 5.9 (SD 10.4), Year 2 = 10.3 (SD 32.9), Year 3 = 5.9 (SD 11.9), Year 4 = 6.0 (SD 15.5), and Year 5 = 12.3 (SD 37.2). In all, 20% of the study group accounted for 85% of the total number of days rehospitalized.

The average monies spent on rehospitalization per person, per year was \$14 197 (SD \$24 710, median \$2750). However, once again this mean was inflated by a number of extreme values: in six cases the annualized mean was greater than \$51 693. With the three most extreme values excluded, the mean was \$10 006 (SD \$16 320). Similar to days hospitalized, the top 20% of the sample ($n = 12$) accounted for 77% of the annualized monies spent on rehospitalization. Although the mean annual days rehospitalized differed by impairment group (see Table 1), only when the ASIA D group was compared to the other two groups combined ($M = 11.8$) was a statistically significant difference observed: $t\ (47.6) = -3.11$, $P < 0.01$, equal variance not assumed. Means remain significantly different ($P < 0.01$) when comparisons were made with the three most expensive cases excluded. The mean annual payments for rehospitalization differed substantially by impairment group (\$11 729 for High, \$18 576 for Low and \$4416 for ASIA D); however, only when the ASIA D group was compared with the other two groups combined ($M = \$17\,385$) were statistically significant differences observed: $t\ (58.6) = -2.87$, $P < 0.01$, equal variance not assumed. This was also the case after the three most expensive cases were excluded ($P < 0.05$).

The relationships between the various risk factors and rehospitalization rates are presented in Table 1. When comparisons of the mean annual number of rehospitalizations by impairment type were conducted, it was found that those within the ASIA D category had significantly fewer rehospitalizations in comparison with the others: $t(56.1) = -3.24$, $P = 0.01$, equal variance not assumed. The average rate of rehospitalization for

Table 1 Risk factors by mean rehospitalization rates and mean associated in-patient days

Risk factor	n	*Annual rehospitalizations M (SD)*	*First-year rehospitalizations M (SD)*	*Subsequent-year rehospitalizations M (SD)*	*Annual in-patient days M (SD)*	*Annual preventable rehospitalizations M (SD)*	*Length of stay M (SD)*
Impairment type							
High tetraplegia	8	0.67 (0.82)	1.20 (0.84)	6.55 (1.09)	8.19 (13.19)	0.30 (0.69)	8.43 (10.15)
Low tetraplegia	38	1.01 (1.21)	0.76 (1.22)	1.09 (1.25)	12.52 (24.46)	0.54 (0.75)	12.20 (25.35)
ASIA D	15	0.30 (0.49)*	0.78 (0.83)	0.21 (0.36)*	1.14 (2.25)*	0.02 (0.06)*	4.00 (4.58)
Age (years)							
19–29	22	0.74 (1.24)	0.71 (1.33)	0.61 (0.94)	6.27 (12.42)	0.22 (0.54)	7.92 (10.04)
30–44	18	0.72 (0.93)	0.72 (0.79)	0.85 (1.33)	13.88 (31.89)	0.43 (0.76)	18.90 (42.51)
45+	21	0.91 (1.00)	1.10 (0.99)	0.95 (1.11)	8.14 (13.59)	0.51 (0.72)	8.60 (9.56)
Place of residence							
Metropolitan	44	0.89 (1.10)	0.96 (1.17)	0.90 (1.15)	10.87 (22.74)	0.46 (0.74)	8.82 (25.30)
Nonmetropolitan	16	0.58 (0.96)	0.50 (0.71)	0.61 (1.07)	5.03 (11.84)	0.20 (0.47)	11.50 (10.83)
Gender							
Male	55	0.64 (1.08)	0.85 (1.08)	0.47 (1.16)	9.55 (21.07)	0.38 (0.68)	11.33 (23.13)
Female	6	0.81 (0.88)	0.00 (0.00)	0.85 (0.64)	5.61 (12.46)	0.42 (0.66)	10.85 (14.95)

*ASIA D significantly different at $P<0.05$ when compared to all non-ASIA D cases

the first year of injury was relatively consistent across impairment levels. However, in subsequent years the mean rate of rehospitalization was significantly lower for the ASIA D group ($P<0.05$) and tended to be lower for the High Tetraplegia group in comparison to the Low Tetraplegia group. When impairment groups were compared, substantial differences in the mean number of days hospitalized per year were observed; however, these differences were not statistically significant. The only exception was when the ASIA D group was compared with the rest after excluding the top three outliers: mean inpatient days were 11.7 *versus* 6.7, $t=47.6$, $P<0.01$.

According to the ERS 2003 urban–rural continuum coding system, 43% of the sample was defined as living in a metropolitan county of 1 million or more, 31% in a metropolitan county of between 1 million and 250 000 population, and the remainder (26%) residing in a nonmetropolitan county. When comparisons of annual rate of rehospitalization were made, no statistically significant differences were observed between those living in metropolitan *versus* nonmetropolitan settings. Nor was there a statistically significant difference observed in the mean annual days rehospitalized. With the top three cases excluded, the average annual days hospitalized for those in a metropolitan county was 5.5 days – very similar to the nonmetropolitan group.

Although the mean annual time the 30–44 years age group spent rehospitalized was 10 days more than for the other two age groups, this difference was not statistically significant. Similarly, no significant age-related differences were observed with regard to the mean annual number of rehospitalizations, rehospitalizations in the first year of injury, or the average of subsequent years. No statistically significant difference was observed with regard to average annual days hospitalized when comparisons based on gender were made. Nor were there statistically significant differences in the annual rate of rehospitalization.

Descriptive information relating to length of stay and cost of the rehospitalization cross-tabulated by reason for admission is presented in Table 2. Length of stay for dermatological, cardio-respiratory and rehabilitation admissions averaged longer than a week. Rehospitalizations for dermatological reasons were by far the longest and most expensive: mean of 27.7 *versus* 8.2 and 7.5 days, respectively, and average cost of $35 542 *versus* $12 020 for all other reasons. Orthopedic problems were also a common and costly reason for rehospitalization; average payment = $20 555 and accounting for 18% of all rehospitalization costs. The most common reasons for multiple rehospitalizations in a single year were dermatological and orthopedic. The number of rehospitalizations observed in each of the study years is presented in Table 3. The frequency of rehospitalization for urological problems showed a trend to increase in later years. The opposite is true for orthopedics and spasticity management (neurology), which showed a decrease as time progressed. No statistically significant differences were observed when the comparisons were made between impairment type, age, place of residence, gender and length of rehospitalization (see Table 1 for group means).

Regarding the potential preventability of rehospitalizations: 48% ($n=58$) were categorized as not preventable, 47% ($n=56$) were potentially preventable, and in six instances insufficient information was available to determine preventability. Rehospitalizations for a potentially preventable reason were experienced by 38%

Table 2 Average length of stay (days) and payments (Year 2000 dollars) for rehospitalizations ($N = 120$)

Reason for rehospitalzation	n	*Length of rehospitalization (days)*				*Daily cost (Year 2000 dollars)*				*Overall cost (Year 2000 dollars)*			
		Mean	*SD*	*Median*	*Range*	*Mean*	*SD*	*Median*	*Range*	*Mean*	*SD*	*Median*	*Range*
Dermatology	28	27.7	42.6	9.5	1–174	1827	988	1616	756–5607	35 542	52 778	15 145	1632–220 921
Orthopedics	21	6.6	7.2	5.0	1–30	6018	7997	3331	790–37 130	20 555	17 233	16 115	3665–79 093
Urology	17	6.3	5.7	5.0	1–25	1429	1006	1329	112–3568	7099	6998	4348	346–24 979
Cardio-respiratory	13	8.2	10.2	6.0	1–40	1441	634	1292	721–2581	14 001	25 138	6064	1761–95 981
Spasticity	11	4.8	4.3	3.0	1–16	2771	3628	1774	641–13 456	10 842	10 790	8868	1281–38 281
Gastrointestinal	6	4.8	4.0	3.5	1–11	2655	1460	2838	817–4666	11 187	13 163	6566	4458–37 972
Rehabilitation	4	7.5	3.7	7.5	3–12	919	560	1049	147–1431	7413	6578	7057	1032–14 506
Pain management	3	2.7	1.5	3.0	1–4	2121	934	1616	1548–3198	4746	1500	4848	3198–6192
Infection	3	6.0	2.7	7.0	3–8	1019	685	1238	251–1568	5989	4358	8663	754–12 542
Other	8	2.6	1.9	2.0	1–6	7161	17 181	1211	128–49 658	9018	16 591	3146	128–49 658
Unknown	6	7.7	3.5	6.5	4–14	1115	279	897	757–1538	7851	4355	5834	3515–13 843
Overall	120	10.9	22.7	5.0	1–174	2861	5823	1543	112–49 658	18 209	30 592	7498	128–220 921

of study subjects. Of those readmitted for any reason ($n = 38$), 60% experienced at least one rehospitalization for a potentially preventable cause. The mean length of stay was found to be significantly longer in the case of the potentially preventable rehospitalizations compared to the nonpreventable ones: 17.3 *versus* 5.0 days, $F\,(1,\,112) = 8.51$, $P < 0.01$. In total, study subjects spent 1305 days in hospital following their initial discharge; of these 970 (74%) were associated with rehospitalizations that had the potential to be prevented. A total of \$2 185 201 was spent on rehospitalizations. Of this, \$1 395 754, (64%) was spent on rehospitalizations that had the potential to be prevented.

Of the rehospitalizations that occurred in the first year following the injury, 28% ($n = 8$) were classified as potentially preventable. This percentage increased in later years: 56% in Year 2 ($n = 14$), 50% in Year 3 ($n = 11$), 54% in Year 4 ($n = 7$), and 64% in Year 5 ($n = 16$). Comparing first year with subsequent years resulted in the identification of a statistically significant difference: 28 *versus* 57%, $\chi^2 = 7.22$, $P < 0.01$. When between-group comparisons were made, it was found that those in the Low Tetraplegia group had a significantly higher rate of potentially preventable rehospitalization than did those in the ASIA D group: $F\,(2,\,58) = 3.60$, $P < 0.05$. No significant differences in the annual rate of preventable rehospitalization were observed between males and females. Although the rate of potentially preventable rehospitalization showed a trend towards increase with age, the trend was not found to be significant. There was also no statistical difference found with regard to the place of residence.

Based on the categorization method used, it was deemed that 100% ($n = 28$) of the dermatological, 76.9% ($n = 10$) of the caridiorespiratory, 76.5% ($n = 13$) of the urological, 33.3% ($n = 1$) of the infections, 16.7% ($n = 1$) of the gastrointestinal, and 9.1% ($n = 2$) of the orthopedic rehospitalizations were potentially preventable. In total, 23% ($n = 14$) of the study group were readmitted for dermatological reasons during the period for which data were available. In several cases, two and three rehospitalizations a year were observed. In total, 49% of the monies spent on rehospitalizations were dermatological related. The only factor found to relate to whether or not a person was readmitted for dermatological reasons was identified when comparisons were made between the Low Tetraplegia group and the ASIA D group, of which 34 and 0%, respectively, were readmitted for dermatological reasons. (In all, 13% of the High Tetraplegia group was readmitted at some stage for dermatological reasons.) Rehospitalization for dermatological reasons was not found to relate to age, place of residence or gender.

Discussion

The current study highlights the frequency with which people with tetraplegia are rehospitalized after initial injury. Close to two-thirds of study participants had been rehospitalized at least once following discharge

Table 3 Reasons for rehospitalizations over the 5-year study period

Reason	*Year 1 (O = 35)*	*Year 2 (O = 33)*	*Year 3 (O = 30)*	*Year 4 (O = 29)*	*Year 5 (O = 33)*	*Overall (O = 160)*	*% of all admissions*
Dermatology	5	9	7	2	5	28	23.3
Orthopedics	9	4	2	3	3	21	17.5
Urology	1	2	2	5	7	17	14.2
Cardio-respiratory	3	3	3	0	4	13	10.8
Spasticity	2	4	3	1	1	11	9.2
Gastrointestinal	2	1	2	1	0	6	5.0
Rehabilitation	1	0	1	0	2	4	3.3
Pain management	1	1	0	0	1	3	2.5
Infection	2	0	1	0	0	3	2.5
Other	3	1	1	1	2	8	6.7
Unknown	0	0	2	4	0	6	5.0
Total	29	25	24	17	25	120	100.0

O = years of data

from initial rehabilitation. This figure is slightly higher than the rates that have been reported in the SCI literature, which range from 26 to 57%. The higher percentage is likely to be related to the current study's focus on people with tetraplegia. Prior studies have included those with paraplegia, and people with these lower-level injuries have been found to experience fewer rehospitalizations.[10] One survey-based study that included predominately tetraplegia cases (93%) produced results similar to those of the current study, reporting that 57% had at least one rehospitalization in the year prior to the survey.[2] Another survey-based study that reported on those with tetraplegia, found that 41.5% of those with complete lesions and 35% with incomplete lesions were rehospitalized the year prior to the survey.[10] The lower percentage of rehospitalizations in this group may be related to limiting the study population to those who are 3 or more years post injury. Along with previous research, the current study found a decrease in the frequency of rehospitalizations over time.[11–13]

In the first year following injury, the rate of rehospitalization was highest and the rate either varied or decreased over time for the different types of rehospitalizations. The only exceptions to this were for urology-related rehospitalizations, which increased in later years. The majority of urology-related illnesses have the potential to be either prevented or aggressively managed. With appropriate resource allocation, rehospitalizations might be avoided, and thus the burden of injury may be reduced.

The average annual length of stay in the current study (9.2 days) is similar to that reported in previous studies by Harvey *et al*,[10] and Ivie and DeVivo,[13] but lower than that of Young and Northup.[14] Harvey *et al* reported that for those with complete tetraplegia, the average number of days spent in hospital annually was 8.2 days, and for those with incomplete tetraplegia, the average was 10.6 days.[10] Ivie and DeVivo reported an average length of stay during the year prior to the survey of 11.6 days. A study by Young and Northup of tetraplegic SCI cases injured in the mid-1970s found an average length of stay of 20 and 12 days in Years 2 and 3, respectively. The shorter length of stay in the current study may be explained by DeVivo *et al*'s report that found that length of stay has decreased over time since the early 1970s.

The annual cost of rehospitalization per study participant can be compared with the figures of DeVivo *et al*,[15] who reported the mean annual charges after the first year postinjury for tetraplegia SCI cases (adjusted to Year 2000 dollars). The costs in the current study were lower for the High Tetraplegia group ($11 729 *versus* $19 583, respectively), but higher for the Low ($18 576 *versus* $6938) and ASIA D ($4416 *versus* $2852) groups. The differences are most likely explained by the highly skewed cost as reported by others in prior studies.[5,10,12,15] However, further comparisons with the other studies are difficult to make as the methods, including the ascertainment of costs and services included as part of the rehospitalization, varied across studies. For example, Johnson *et al* included extended care and general follow-up services as part of the rehospitalization costs.[12]

The current results are similar to those of Young and Northrup,[14] who found that approximately 20% of those affected by SCI account for 80% of rehospitalization resource usage. Unfortunately, the ability to differentiate these individuals from others based on demographic characteristics commonly contained within administrative databases was not possible. Further research aimed at the early identification of such individuals may prove useful in terms of identifying individuals in need of early intervention services.

The current findings are consistent with past research in that little association was found between demographic factors and rates of rehospitalization.[5,16–18] The finding that those with an ASIA D-graded impairment had fewer rehospitalizations is also consistent with past research.[3] For example, Davidoff found that those with Frankel Grades C and D were less frequently readmitted. Although some investigators have found an association between age and rehospitalization rates,[2,19] the current study and others[3,5] did not observe this

effect. Consistent with past research, gender was found to have no impact on rehospitalization rates.

Although Anson and Shepard found that persons attending outreach clinics (typically people who lived in small towns and remote areas) had more medical problems than those in metropolitan areas,[20] the current findings did not indicate that people residing in nonmetropolitan areas are more likely to be rehospitalized. If anything, there was a trend towards those in nonmetropolitan areas to be less likely to be rehospitalized. An analysis of all medical problems is beyond the scope of this study; however, current findings suggest that the greater number of health problems experienced by nonmetropolitan residents does not result in a greater frequency of rehospitalization. One possible explanation for this may be found in the way services are delivered. Often outreach services are offered only at scheduled times. This may mean that those with SCI in rural areas are more likely to attend clinics when they are available and have their medical problems diagnosed and treated earlier, meaning that their health does not deteriorate to the extent where rehospitalization is required. Further research into the impact of living in a rural setting on health care behaviors may prove insightful with regard to maintained health and managing medical problems so that they do not result in rehospitalization.

Although this study focused on those with tetraplegia, the observed average length of stay per rehospitalization (ie, 10.9 days) is consistent with findings from the majority of past similar research, which has investigated all types of SCI: reported lengths of stay include 11.9,[5] 11.1,[19] 12.3,[3] and 13.7 days.[15] An exception is the 1985 work of Meyers *et al*, which found that the average length of stay was 34.7 days.[2] An explanation for this disparity may be the sampling procedure used in that participants in the Meyers 1985 study were all clients of independent living centers and all wheelchair users. An explanation for why the currently observed lengths of stay tend to be shorter may be found in DeVivo's (1991) report indicating that hospital stays are shortening: in 1980, the average length of stay was 15.5 days whereas in 1988 it was 11.7 days.[11] This is not contradicted by Middleton *et al*'s most recent study (2004), which reported the average length of stay to be 15.5 days as the data they present dates back to 1989.[21]

The current finding that the most common rehospitalizations were for dermatology, orthopedic, urological and cardio-respiratory reasons is consistent with past research.[3,6,21,22] One difference, however, was in the rate of rehospitalization for dermatological reasons (23% of all rehospitalizations), which was higher than that reported in most studies, for example, 3,[6] 9,[21] and 17%.[3] In these studies, the rate of rehospitalization for urological reasons was higher than that currently observed: 43,[6] 24,[21] and 41%[3] with the current figure being 14%. As these three studies came from Commonwealth countries, it may be possible that differences reflect differences in treatment practices. Support for this contention can be found in the fact that two of these studies report a mean length of stay well in excess of the current figures: 51[21] and 78 days[6] *versus* the current finding of 28 days. While the current percentage of total rehospitalization is somewhat higher, the finding that dermatologically related rehospitalizations account for a disproportionate amount of the hospitalized days and monies spent has been found by other researchers. Few researchers have reported rehospitalization cost detail. Davidoff *et al*'s report that the average cost per readmission was $9683[5] is substantially lower than that currently observed; however, adjusting the reported figure to Year 2000 dollars brings it more in line with current findings: $16 945 *versus* $18 209.

Of the studies that have investigated rehospitalizations following SCI, only two, Davidoff[5] and Perhouse,[4] have differentiated between preventable and nonpreventable cases. Although different criteria were applied, results of these studies suggest that between 9%[4] and 34%[5] of SCI-related rehospitalizations were potentially preventable. In the Perhouse study, this figure increases to 18% if urinary tract infections are classified as potentially preventable, as was the case in the Davidoff study. Perhouse *et al* noted that the identification of preventable rehospitalization relies heavily upon the opinion of medical professionals. This highlights the subjectivity involved with the classification of potentially preventable rehospitalizations and the reliability problems that are to be expected when judgments are made without standardized definitions of 'preventable'.

The current study employed the same definition of 'preventable' as was employed by Davidoff, with the addition of deep vein thrombosis (DVT). Had Davidoff *et al* included rehospitalization for DVT as preventable, 49% of their rehospitalizations would have been classified as preventable – very similar to the current findings (ie, 47%). Had Perhouse *et al* included rehospitalizations for DVT, urinary tract infections and indwelling catheter complications as potentially preventable, their figure would have been 27% and these potentially preventable rehospitalizations would have accounted for 43% of the total days rehospitalized.

The finding that 74% of days rehospitalized and 64% of monies spent on rehospitalization had the potential to be prevented suggests that much can be done to reduce the burden of SCI. Although Johnson[23] suggested targeting the most frequently reported body systems (ie, urological, skin, pain, gastrointestinal) and the most expensive (neurological, skin, respiratory, orthopedic) for intervention, it would seem that it would also be important to target rehospitalizations that are longest in duration and that have the potential to be prevented. Based on the current findings, it may be suggested that, both in terms of reducing the number of days in hospital and the monies spent on rehospitalization, dermatologically related rehospitalizations hold the greatest potential for reducing the burden of injury.

Despite the number of studies that have attempted to determine risk factors for pressure sores, consistent with the current research, few significant associations have been observed. Although Middleton *et al*[21] did recently report that pressure sores were more common in the

younger patients, this was not replicated in this research. Current findings do, however, suggest that those with ASIA D-graded impairments are less in need of services aimed at preventing rehospitalizations, and although the percentage of preventable rehospitalizations is lower in the first year of injury, absolute numbers suggest that intervention services are as appropriate in the first year of injury as they are in later years.

The current lack of observed association between demographic factors and readmission adds support to the contention that psychosocial factors may play an influential role in the occurrence of pressure sores.[17,18,24] Owing to cost cutting throughout the health sector, the amount of time people are in rehabilitation after an SCI has declined.[1] Current rehabilitation strategies aim to minimize disability with therapies focused on physical restoration and function. A limitation of this approach to the rehabilitation of people with SCI is the overwhelming focus on outcomes, such as physical independence, at the expense of other important areas such as cognitive styles developed by specialized psychosocial interventions.[1] Psychosocial interventions may potentially minimize the occurrence of secondary conditions and rehospitalization following discharge from rehabilitation. The psychosocial rehabilitation model is a holistic approach based on the promotion of behavioral and psychological adaptation to living with SCI. Interventions involved with psychosocial-based rehabilitation typically include problem-solving skills training, social skills training, recreation therapy and health promotion education. The integration of psychosocial interventions into the rehabilitation of people after SCI may potentially reduce the rate of rehospitalization.

Strengths, limitations and further research

This study adds to the understanding of the reasons for rehospitalization following tetraplegia through its use of workers' compensation data. As the workers' compensation provider's coverage is continuous and comprehensive for all SCI-related care, virtually all associated costs and lengths of stay were available for analysis. The current study advances on the past research through the inclusion of new detailed information on costs and length of stay broken down by various demographic characteristics. However, the small sample size means that any conclusions drawn regarding the likely cost of particular types of admissions can only be tentative. In addition, the study was limited by its dependence on administrative data, meaning that only a limited investigation of risk factors for rehospitalization could be undertaken. Further research looking more specifically into individuals' psychosocial characteristics and health care practices may be more successful at identifying risk factors for rehospitalization. The study was also limited by its ability to separate 'preventable' from 'nonpreventable' rehospitalizations, for in a few cases, the available information lacked sufficient detail for such a conclusion to be drawn. With further detail, the percentage of preventable rehospitalization may have been found to be higher. Further studies involving interviews with patients and their health care providers might overcome this problem.

The generalizability of the current findings to all persons with tetraplegia remains to be determined. Although the participating insurer accounts for 8–10% of the private workers' compensation market share, the extent to which the insurer represents all industries and occupations is not known. Regarding the reported cost of rehospitalization, it should be noted that the figures presented did not include the cost of outpatient follow-up care or medications and supplies; thus, it is likely that the reported figures substantially under-represent the total expenditure associated with rehospitalization.

Conclusion

Although the physiologic changes resulting from SCI have been found to increase lifelong susceptibility to health problems, hospital readmission is not a necessary consequence of living with SCI. Secondary health problems are usually a precursor to hospital readmission for people with SCI. As such, the prevention of these conditions is central to addressing the issue of rates of rehospitalization. Further investigation into strategies that can be used to prevent rehospitalization is fundamental to improving outcomes for people with SCI.

References

1 Krause J. Secondary conditions and spinal cord injury: a model for prediction and prevention. *Topics Spinal Cord Injury Rehabil* 1996; **2:** 58–70.
2 Meyers A *et al*. Rehospitalization and spinal cord injury: cross-sectional survey of adults living independently. *Arch Phys Med Rehabil* 1985; **66:** 704–708.
3 Savic G, Short D, Weitzencamp D, Charlifue S, Gardner B. Hospital readmissions in people with chronic spinal cord injury. *Spinal Cord* 2000; **38:** 371–377.
4 Pershouse K, Cox R, Dorsett P. Hospital readmissions in the first two years after initial rehabilitation for acute spinal cord injury. *Topics Spinal Cord Injury Rehabil* 2000; **6:** 23–33.
5 Davidoff G *et al*. Rehospitalization after initial rehabilitation for acute spinal cord injury: incidence and risk factors. *Arch Phys Med Rehabil* 1990; **71:** 121–124.
6 Vaidyanathan S *et al*. A review of the readmissions of patients with tetraplegia to the Regional Spinal Injuries Centre, Southport, United Kingdom, between January 1994 and December 1995. *Spinal Cord* 1998; **36:** 838–846.
7 Webster B, Giunti G, Young A, Pransky G, Nesathurai S. Work-related tetraplegia: causes of injury and annual medical costs. *Spinal Cord* 2004; **42:** 240–247.
8 Young A, Webster B, Giuntu G, Pransky G, Nesathurai S. Medical services provided following compensable work-related tetraplegia. *Spinal Cord* 2004; **42:** 248–260.
9 US Department of Labor. Consumer Price Index – All Urban Consumers, US City Average, Medical Care, Series Id: CUUR0000SAM. *Bureau of Labor Statistics*. Available from URL: http://www.data.bls.gov/PDQ/servlet/SurveyOutputServlet?data_tool=latest_numbers&series_id=CUUR0000SAM&output_view=pct_1mth.

10 Harvey C, Wilson SE, Greene CG, Berkowitz M, Stripling TE. New estimates of the direct costs of traumatic spinal cord injuries: results of a nationwide survey. *Paraplegia* 1992; **30:** 834–850.
11 DeVivo M, Richards J, Stover SL, Go B. Rehabilitation medicine: adding life to years. *West J Med* 1991; **154:** 602–606.
12 Johnson R, Gerhart K, McCray J, Menconi J, Whiteneck G. Secondary conditions and spinal cord injury in a population-based sample. *Spinal Cord* 1998; **36:** 45–50.
13 Ivie C, DeVivo M. Predicting unplanned hospitalizations in persons with spinal cord injury. *Arch Phys Med Rehabil* 1994; **75:** 1182–1188.
14 Young J, Northup N. Re-hospitalization in years two and three following spinal cord injury. *SCI Digest* 1980; **1:** 19–26.
15 DeVivo M, Whiteneck G, Charles E. 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, Maryland 1995, pp. 234–271.
16 Cull J, Smith O. A preliminary note on demographic and personality correlates of decubitus ulcer incidence. *J Psych* 1973; **85:** 225–227.
17 Lamid S, El Ghatit AZ. Smoking, spasticity and pressure sores in spinal cord injured patients. *Am J Phys Med* 1983; **62:** 300–306.
18 Anderson TP, Andberg MM. Psychosocial factors associated with pressure sores. *Arch Phys Med Rehabil* 1979; **60:** 341–346.
19 Meyers AR, Branch LG, Cupples LA, Lederman RI, Feltin M, Master RJ. Predictors of medical care utilization by independently living adults with spinal cord injuries. *Arch Phys Med Rehabil* 1989; **70:** 471–476.
20 Anson C, Shepherd C. Incidence of secondary complications in spinal cord injury. *Int J Rehabil Res* 1996; **19:** 55–66.
21 Middleton JW, Lim K, Taylor L, Soden R, Rutkowski S. Patterns of morbidity and rehospitalisation following spinal cord injury. *Spinal Cord* 2004; **42:** 359–367.
22 Exner G, Meinecke FW. Trends in the treatment of patients with spinal cord lesions seen within a period of 20 years in German centers. *Spinal Cord* 1997; **35:** 415–419.
23 Johnson RL, Brooks CA, Whiteneck GG. Cost of traumatic spinal cord injury in a population-based registry. *Spinal Cord* 1996; **34:** 470–480.
24 Richards J. Pressure sores in SCI: psychosocial correlates. *SCI Digest* 1981; **3:** 11–17.