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ORIGINAL ARTICLE

Health system factors associated with rehospitalizations after traumatic spinal cord injury: a population-based study

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Study design: This is a cohort study with 1-year follow-up.
Objectives: The aim of this study was to examine 1-year rehospitalization rates following spinal cord injury (SCI) onset and health system factors affecting rehospitalization.
Methods: All persons who had an acute care hospitalization for traumatic SCI in Ontario between 1 April 2003 and 31 March 2006 were identified according to International Classification of Diseases, Tenth Revision codes and followed for 1 year following acute care discharge through record linkage of administrative databases. Index cases with an SCI admission the year before 2003 as well as persons who died within 1 year after the index hospitalization were excluded from the analysis. Factors associated with 1-year rehospitalization were assessed using multivariate logistic regression analyses and included age, sex, rurality, length of stay, comorbidity, level of injury, discharge disposition, in-hospital complication, physician visits and specialist visits measure and etiology of injury.
Results: A total of 559 individuals met the inclusion criteria and 27.5% ($n=154$) were rehospitalized 1 year after initial acute care discharge. Factors significantly associated with 1-year rehospitalization were length of stay, rural residence, 50+ outpatient physician visits and 50+ specialists visits following the index admission. The main causes of rehospitalization were musculoskeletal, respiratory, gastrointestinal and urological disorders.
Conclusion: This study presents recent data on rehospitalization and yet rehospitalization rates continue to remain high. Our findings have significant implications for healthcare policy and planning in Ontario, Canada with respect to the management of SCI to achieve optimal health outcomes, in particular in rural areas.
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Keywords: spinal cord injury; readmission; hospitalization; databases

Introduction

Rehospitalization following spinal cord injury (SCI) has been studied in a number of countries including the United States, Canada,[1] Turkey,[2] Britain, the Netherlands,[3] Italy[4] and Australia (Table 1).[5] These studies have reported that approximately one-third of persons with a traumatic SCI will be rehospitalized each year.[6] These hospitalizations are not only costly to the healthcare system but also to the individual with SCI in terms of increased difficulty in obtaining or sustaining employment or becoming involved in other gainful or leisure activities and a reduced quality of life.[6] Examining the rates of and increasing our understanding of the reasons for rehospitalization is important for identifying those at greatest risk to predict the use of inpatient resources and develop preventive strategies in the long term. The US Model Systems programs have attributed the decline in annual rehospitalization rates and in length of stay (LOS) to advances in prevention of secondary medical complications and improved treatment efficiency.[7] However, as LOS decreases, the potential for increased rehospitalization becomes a concern. Also, for persons with SCI, rehospitalization is a major obstacle to independent living and maintaining gainful employment.[8]

There are a number of methodological limitations with the prior studies. First, most are cross sectional and report

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Table 1 Summary of studies on rates of and reasons for rehospitalization

Author	*Data source/country*	*Study period*	*Factors associated with or predictors of rehospitalization*	*Rehospitalization trend*
Cardenas *et al.*[7]	US MSCIS centers	1995–2002	Diseases of the genitourinary system, including urinary tract infections	The rate of rehospitalization was significantly higher at year 1, 5 and 20 for those who were discharged to a skilled nursing facility after acute rehabilitation
Charlifue *et al.*[9]	US MSCIS	1973–1998	Being older at injury and being unmarried, having an indwelling catheter, having a more severe SCI and having been hospitalized 5 years earlier	The number of days rehospitalized and frequency of rehospitalizations decreased as time passed
Davidoff *et al.*[10]	Acute SCI patients who completed initial rehabilitation at a regional model SCI care system (Ann Arbor, MI)	1980s	Less education and a substantially longer initial rehabilitation LOS	39% were readmitted at least once by 1-year after discharge from rehab
Dorsett and Geraghty[11]	Spinal Injuries Unit of the Queensland Spinal Cord Injuries Service (Australia)	1992–1994 to 2002–2004	Pressure sores, urinary tract infections, bowel obstructions, pneumonia, surgical removal spinal instrumentation, fractures and renal tract calculi	The overall rehospitalization rate was 32.6% in the first 2 years and 52% by the 10th year
Dryden *et al.*[1]	Alberta Ministry of Health and Wellness (Canada)	1992–1994	Urinary tract infection (47.6%), pneumonia (33.8%), depression (27.5%) and decubitus ulcer (19.7%)	Persons with SCI were rehospitalized 2.6 times more often than a control group
Franeschini *et al.*[4]	Two rehabilitation centers (Udine and Trevi) and a Spinal Injuries Unit (Torino, Italy)	1989–1994	—	25% has been hospitalized again
Johnson *et al.*[12]	Colorado Spinal Cord Injury ENS (United States)	1986–1993	Spasticity or pain (25%), and pressure sores (10%) at the first, third and fifth year after injury	—
Middleton *et al.*[5]	NSW Department of Health Inpatient Statistics Collection and RNSH Spinal Cord Injuries Database (Australia)	1989–1990 and 1999–2000	Genitourinary (24.1%), gastrointestinal (11.0%), further rehabilitation (11.0%), skin-related (8.9%), musculoskeletal (8.6%) and psychiatric disorders (6.8%)	Overall rehospitalization rates were high in the first 4 years after initial treatment episode
Vaidyanathan *et al.*[13]	Hospital records of patients with tetraplegia readmitted to the Regional Spinal Injuries Centre (Southport, UK)	1994–1995	Urinary tract disorders (43.43%)	—

Abbreviations: ENS, Early Notification System; LOS, length of stay; MSCIS, Model Spinal Cord Injury Systems; RNSH, Royal North Shore Hospital; SCI, spinal cord injury.

rehospitalizations using individuals with varying lengths of time since injury. Two, many are reporting on a single center or healthcare provider thereby limiting generalizability.[2,6,14] Three, some have relied on patient surveys and may be subject to recall bias.[4,7,9,12,15] Another issue affecting studies examining rehospitalization is the recency of the cohort. The study by Dryden *et al*. identified cases over the 2-year period 1 April 1992 to 31 March 1994 and thus may not reflect improvements in the treatment of SCI in the last 14 years. Similar to this study we overcome the issue of generalizability by using a population-based cohort study of traumatic SCI in Ontario, Canada. The main objective was to examine 1-year rehospitalization rates following onset of SCI and health system factors affecting rehospitalization. We limited our analyses of rehospitalization to the first year after discharge because rates are higher in the first year.[11] This is the final study in a three-part investigation of SCI incidence, healthcare utilization and rehospitalization in Ontario, Canada.

Materials and methods

Setting

Ontario is located in central Canada and is the most populous province representing 40% of the Canadian population or 11 million inhabitants. Ontario has a universal publicly funded healthcare system.

Data sources

The administrative healthcare databases in Ontario allowed for selection of cases, determination of individual and health system factors and outcome ascertainment. Hospitalization records were obtained from the Canadian Institute for Heath Information Discharge Abstract Database, which contains a detailed record of all hospital admissions from over 200 hospitals in Ontario. Each record in the data set contains a patient's health card number, age, sex, postal code, date of admission, date of discharge, most responsible diagnostic codes as well as secondary and tertiary diagnostic codes

based on International Classification of Diseases, Tenth Revision (ICD-10) codes. The Ontario Health Insurance Plan provided physician billing information for outpatient visits, and the Ontario Registered Persons Database contained basic demographic and vital statistics information, including death date, for each Ontario resident. The National Ambulatory Care Resource System database provided information on all visits to emergency departments (EDs). All patients discharged to short-term and long-term subacute care were identified in the National Rehabilitation Reporting System (short stay inpatient rehabilitation) and the Continuing Care Reporting System (chronic care rehabilitation). All databases were linked anonymously using encrypted individual health card numbers. This study was approved by the Institute for Clinical Evaluative Sciences and the research ethics board of the Sunnybrook Health Sciences Centre.

SCI cases

Cases included in this retrospective cohort study were patients admitted to Ontario hospitals between 1 April 2003 and 31 March 2006 for a traumatic SCI. Index cases were identified from acute care hospitalization records using the following ICD-10 diagnostic codes for SCI: injury to cervical spinal cord (S14.0, S14.10, S14.11, S14.12, S14.13, S14.18, S14.19), injury to the thoracic spinal cord (S24.0, S24.10, S24.11, S24.12, S24.13, S24.18, S24.19), injury to lumbar spinal cord (S34.0, S34.10, S34.11, S34.12, S34.13, S34.18, S34.19), other SCI S34.30 (laceration of cauda equine), S34.38 (other and unspecified injury of cauda equine), T06.0 (injuries of brain and cranial nerves with injuries of nerves and spinal cord at neck level) and T06.1 (injuries of nerves and spinal cord involving other multiple body regions). Records were excluded if age at index admission for SCI <18 years, gender was missing, record of traumatic SCI in the year before 1 April 2003, index admission was not at an SCI center, discharged after March 2006, if the individual died within 1 year after index discharge.

Variables

Information abstracted from these databases was categorized as individual, health system and outcome variables. Individual variables included age, sex, injury level, concurrent traumatic brain injury (TBI) and Charlson Comorbidity Index. The Charlson index is the most well-known index of comorbidity and has been validated in administrative databases.[16–18] Charlson used statistical methodology to determine and then weigh the 16 illnesses that most predicted 1-year mortality to produce a summative scale that yields a continuous variable from 0 to 31. The scores are typically skewed far right, because most patients have a score of zero. The Charlson index is widely used in all aspects of outcome research and has been translated to an administrative data format.[19] Variables categorized as healthcare system and healthcare utilization included in-hospital complication, acute care LOS for index injury, direct discharge to short-stay or long-stay rehabilitation, ED visits, total number of outpatient physician visits during 1-year follow-up after acute care discharge (all inpatient visits were excluded) by various physician specialties (all specialists, physiatrists, neurosurgeons, urologists, internists and family physicians) and rurality. The Rurality Index of Ontario (RIO) is made up of 10 components that include measures of population size, travel times to referral centers, population to general practitioner (GP) ratios, availability of ambulance and other services, weather conditions, hospital presence and social indicators. The RIO is a scaled index between 0 and 100. Values $\leqslant 45$ are categorized as urban and >45 are categorized as rural.[20] The primary outcome of this study was readmission to an acute care hospital within 1 year following an index admission for SCI. ICD-10 codes were examined at readmission to review reasons for readmission and to determine if the admission was due to secondary complications of SCI. ICD-10 codes were examined at readmission (1 year post-index admission) to review the main reasons for readmission and to determine if the admission was due to secondary complications of SCI. The physiatrist (CC) on our team grouped these codes by system.

Table 2 Individual level demographic and impairment variables by 1-year rehospitalization status

Variables	*Rehospitalized* (N = *154*) n *(%) or mean (s.d.)*	*Not rehospitalized* (N = *405*) n *(%) or mean (s.d.)*	*Total* (N = *559*) n *(%) or mean (s.d.)*	P-*value*
Age (mean years)	50.1 ± 19.1	46.2 ± 18.1	47.3 ± 18.4	0.024*
Sex				0.906
Male	116 (75.3)	307 (75.8)	423 (75.7)	
Female	38 (24.7)	98 (24.2)	136 (24.3)	
Injury level				0.577
Cervical	91 (59.1)	259 (64.0)	350 (62.6)	
Thoracic	40 (26.0)	86 (21.2)	126 (22.5)	
Lumbar	16 (10.4)	46 (11.4)	62 (11.1)	
Other	7 (4.5)	14 (3.4)	21 (3.8)	
Concurrent TBI				0.811
Yes	26 (16.9)	65 (16.0)	91 (16.3)	
No	128 (83.1)	340 (84.0)	468 (83.7)	
Charlson index				<0.001*
0	97 (63.0)	319 (78.8)	416 (74.4)	
1	15 (9.7)	19 (4.7)	34 (6.1)	
2	28 (18.2)	55 (13.6)	83 (14.8)	
3+	14 (9.1)	12 (2.9)	26 (4.7)	

Abbreviation: TBI, traumatic brain injury.
*Significance reported at $P \leqslant 0.05$.

Data analysis

Descriptive statistics were first employed to characterize those readmitted and not readmitted. Multivariate logistic regression analyses were used to model readmission rate to determine factors associated with readmission. All analyses were performed using SAS for UNIX, version 8.2 (SAS Institute, Cary, NC, USA). All statistical tests were performed at the 5% level of significance and were two sided.

Results

A total of 559 incident SCI cases eligible for readmission were identified. During the 1-year follow-up period, 27.5% ($n=154$) patients were rehospitalized in acute care. Table 2 compares the individual level characteristics of the rehospitalized and not rehospitalized groups. Statistically significant differences were seen for age and comorbidity. Compared to their non-readmitted counterparts, readmitted patients were older (50.12 years vs 46.17 years, $P=0.024$), and a greater proportion had higher comorbidity scores (Charlson score of 3+) (9.1 vs 2.9%, $P<0.001$).

Table 3 compares those rehospitalized and not rehospitalized on acute care and access to care variables. Patients with SCI who were rehospitalized had a significantly longer mean acute care LOS during their initial hospitalization (31.58 vs 17.91 days, $P<0.001$), a higher rate of in-hospital complications (41.0 vs 55.2%) and were less likely to be discharged directly home. Patients with SCI who were rehospitalized had significantly higher healthcare utilization. They had twice as many total physician and visits with specialists than their not-rehospitalized counterparts. The mean number of total outpatient physician visits was 49.6 for the rehospitalized group (vs 25.8 for the not-rehospitalized group). The multivariate logistic regression analysis identified four factors that were statistically significantly associated with rehospitalization: longer acute care LOS, living in a rural area, having 50 or more physician visits or specialist visits (Table 4). Patients with SCI living in a rural area were twice as likely (OR = 1.94) to be rehospitalized. Patients with 50 or more physician visits or specialist visits were three and four times more likely to be rehospitalized (OR = 2.95 for 50+ specialist visits; OR = 3.69 for 50+ physician visits). We also reviewed diagnoses codes to determine the reasons for rehospitalization. The main reasons identified were musculoskeletal, respiratory, gastrointestinal and urological disorders, all associated secondary complications of SCI. These results are reported in Table 5.

Table 3 Health system and health-care utilization variables by 1-year rehospitalization status

Variables	*Readmitted (N = 154)* n *(%) or mean (s.d.)*	*Not readmitted (N = 405)* n *(%) or mean (s.d.)*	*Total (N = 559)* n *(%) or mean (s.d.)*	P-*value*
Direct discharge from acute care				0.013*
Home	41 (26.6)	167 (41.2)	208 (37.2)	
Inpatient rehabilitation	103 (66.9)	221 (54.6)	324 (58.0)	
Chronic care rehabilitation	6 (3.9)	8 (2.0)	14 (2.5)	
Other	<5 (2.6)	0 (2.2)	<5 (0.9)	
In-hospital complication				0.003*
Yes	85 (55.2)	166 (41.0)	251 (44.9)	
No	69 (44.8)	239 (59.0)	308 (55.1)	
Rurality				0.095*
Rural	40 (26.0)	73 (18.0)	113 (20.2)	
Urban	114 (74.0)	331 (81.8)	445 (79.6)	
Acute care LOS	31.6 ± 47.2	17.9 ± 21.7	21.7 ± 31.4	<0.001*
Physician visits	48.2 ± 31.7	25.4 ± 20.3	31.7 ± 26.0	<0.001*
Specialists visits	32.6 ± 25.6	15.4 ± 13.1	20.1 ± 19.1	<0.001*
Physiatrist visits	7.8 ± 10.8	5.5 ± 9.3	6.1 ± 9.8	0.014*
Neurosurgeon visits	1.3 ± 2.4	0.9 ± 1.3	1.0 ± 1.7	0.002*
Urologist visits	2.2 ± 3.2	1.4 ± 2.4	1.6 ± 2.7	0.002*
Internist visits	3.5 ± 7.4	1.0 ± 4.0	1.64 ± 5.3	<0.001*
Family physician visits	15.6 ± 17.2	10.0 ± 13.6	11.6 ± 14.9	<0.001*
ED visits	2.0 ± 2.5	0.8 ± 1.5	1.1 ± 1.9	<0.001

Abbreviations: ED, emergency department; LOS, length of stay.
*Significance reported at $P \leqslant 0.05$.

Discussion

Readmission rates following SCI are high following initial rehabilitation ranging from 19 to 57%.[11,21,22] We found a 1-year rehospitalization rate of 27.5% and that longer length of acute care stay, living in a rural area and 50 or more physician visits or specialist visits were significantly associated with rehospitalization. These findings indicate

Table 4 Multivariate logistic regression results of factors associated with rehospitalization following SCI

Factors	*Odds ratio (95% confidence interval)*	P-*value*
Individual level		
Male	1.21 (0.73–2.00)	0.45
Age 70+ years	1.72 (0.95–3.10)	0.07
Injury level		
Cervical	0.54 (0.20–1.49)	0.23
Thoracic	0.70 (0.24–2.03)	0.51
Lumbar	0.83 (0.26–2.60)	0.75
Concurrent TBI	0.83 (0.47–1.48)	0.53
Charlson comorbidity score ⩾3	2.08 (0.83–5.20)	0.12
Health system		
Direct discharge to inpatient rehabilitation	1.28 (0.78–2.11)	0.32
Direct discharge to chronic care rehabilitation	0.91 (0.25–3.29)	0.89
In hospital complication	0.84 (0.50–1.39)	0.49
Acute care LOS	1.01 (1.00–1.02)	0.016
Rural	1.94 (1.18–3.17)	0.0085
Total physician visits 50+	3.69 (1.92–7.08)	<0.0001
Total specialist physician visits 50+	2.95 (1.10–7.93)	0.03

Abbreviations: LOS, length of stay; TBI, traumatic brain injury.

Table 5 Main reasons for rehospitalization 1-year post-index admission

System	*Number of visits (N = 399)* n *(%)*
Musculoskeletal	92 (23.1)
Respiratory	46 (11.5)
Gastrointestinal	44 (11.0)
Urological	42 (10.5)
Cardiovascular	41 (10.3)
Psychological	36 (9.0)
Skin	29 (7.3)
Endocrine	24 (6.0)
Sepsis	13 (3.3)
Renal	12 (3.0)
Hematological	9 (2.3)
Venous thrombosis	6 (1.5)
Gynecological	4 (1.0)

that patients with SCI who are rehospitalized after their acute care stay are extremely high users of physician services; the average rehospitalized patient had weekly outpatient physician visits. The main reasons for these rehospitalizations were secondary complications. The frequency of follow-up visits may reflect unease with pressures to reduce acute care and rehab LOS among medically complex patients.

There have been two studies, Australian and Canadian, that have used record linkage to examine rehospitalization following SCI.[1,5] In the Australian study, Middleton *et al*., using data with the Royal North Shore Hospital SCI Database in New South Wales from 1989–1990 to 1999–2000 in 432 patients, reported an overall rehospitalization rate in the first 12 months after discharge of 36%. In the Canadian study, the cases were from 1992 and 1994 and, in the first year following discharge, 22.5% were rehospitalized, which is similar to the current study. This data are also consistent with the study of Johnson *et al*.[12] that reported that 27.2% of SCI survivors (1 January 1986 and 31 December 1993) in Colorado were rehospitalized in the first year after injury. Similarly, in a cross-sectional study using the US Model SCI System (MSCIS), 26% of patients 1–7 years after injury were hospitalized at least once in the previous year.[6]

Higher rates of rehospitalization have been reported in other studies. Davidoff *et al*.[10] studied all patients with SCI aged 18 years and older admitted to hospital between 1 January 1983 and 31 December 1987 in a regional MSCIS. Of those not lost to follow-up at 1 year, 39% were readmitted at least once.[10] Eastwood *et al*.[15] in a study of 3904 persons discharged from 18 MSCISs from 1990 to 1997 with 1-year follow-up reported an increase in rehospitalization from 29.4 to 38.4%. Similarly, Cardenas *et al*.[7] using more recent data from 16 MSCISs on 8669 persons between 1995 and 2002 reported that the average rate of rehospitalization in year 1 was 55% and between 36 and 38% at the 5-, 10-, 15-, and 20-year follow-ups. Whereas in a study of 1250 male veterans with traumatic SCI between 1970 and 1986 who utilized Veterans Affairs inpatient facilities in the United States at least once within 1 year of their SCI, between 42 and 50% were rehospitalized within the first year after injury.[14] These higher rates in single centers may reflect a more severely injured patient population. Recently, Dorsett and Geraghty[11] conducted chart reviews and interviews for 51 patients who were consecutively discharged between November 1992 and March 1994. The overall rehospitalization rate was about 25% in the first year, 33% by the second year and 52% by the 10th year.

Secondary complications are the main reasons for rehospitalization. They are similar across all studies and include respiratory, skin and urinary conditions and spinal surgery to repair or replace hardware.[1,3–5,7–9,11–13] Many of these complications are considered preventable. Studies have also examined factors associated with rehospitalization. However, it is difficult to compare factors across studies as there have been changes in SCI treatment practices over time and significant differences with respect to study population definitions, age distributions, variables measured and controlled for in the analyses, definitions of rehospitalization, measures of rehospitalization as well as loss to follow-up. Yet, there are some interesting findings. Davidoff *et al*.[10] showed that a readmitted group was less educated and had a substantially longer initial rehabilitation LOS, which is similar to what we found for acute care. Cardenas *et al*.[7] also examined the association between rehospitalization and demographics, injury severity, payer sources, LOS, discharge functional status and discharge residence.[7] There were no significant differences by age; and at year 1, the only two significant predictors of rehospitalization were lower motor Functional Independence Measure at discharge from acute rehabilitation and payer (state or federal programs, OR = 1.5 and health maintenance organizations, OR = 1.4) compared to those with private insurance. In some studies, older age does not appear to be predictor.[6,8,10] In our study, age 70 years and older approached statistical significance. Charlifue *et al*.[9] found a significant effect of older age on rehospitalization among 7981 people with traumatic SCI between 1973 and the end of 1998 in the US National SCI Database. The number of rehospitalizations at year 5 was predicted by being older at injury, unmarried at time of injury, having an indwelling catheter, having a more severe SCI and having been hospitalized 5 years earlier. Other studies also found that having an indwelling catheter predicted rehospitalization.[6,15,23]

Our study had a number of limitations. We examined acute care rehospitalizations only and not readmissions to inpatient rehabilitation. We do not have detailed information on the reason for the rehospitalization and no information on whether the cause was patient or provider initiated. Similarly, we do not have information on American Spinal Injury Association Impairment Scale (AIS) classification or ASIA scores, and therefore cannot make comparisons by impairment severity, nor data on functional outcomes. As the data used were administrative, we have no information on the effects of psychosocial factors, health-related quality of life, education or reported unmet care needs.

Our findings are significant in that they suggest that rehospitalization rates within the first year following injury have not changed in the last 14 years in Canada with about 1 in 4 persons with traumatic SCI being rehospitalized in a year. A possible explanation is that as progress in medical and rehabilitation treatment improves, and LOS decreases, patients with more complex needs are surviving,[13] which could increase the need for readmission and thus explain why there has not been a decrease in the proportion of patients rehospitalized. Thus, the high rate of physician and specialist utilization and the main reasons for rehospitalization being secondary complications indicate that current care practices are not preventing or treating these complications adequately. This is of particular concern in rural areas where there is even less access to healthcare services. Alternately, patients are being followed closely in the community, and subtle/acute changes in health prompt appropriate acute care admission for management of secondary health complications. Future research needs to provide a greater understanding of factors at the individual, healthcare provider and health system level contributing to

these rehospitalizations before effective preventive strategies could be implemented that will in the long term improve the quality and cost of care for persons with SCI.

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