The Economic Burden of Urinary Tract Infection and Pressure Ulceration in Acute Traumatic Spinal Cord Injury Admissions: Evidence for Comparative Economics and Decision Analytics from a Matched Case-Control Study

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Abstract

Secondary complications of spinal cord injury (SCI) are a burden to affected individuals and the rest of society. There is limited evidence of the economic burden or cost of complications in SCI populations in Canada, however, which is necessary for comparative economic analyses and decision analytic modeling of possible solutions to these common health problems. Comparative economic analyses can inform resource allocation decisions, but the outputs are only as good as the inputs. In this article, new evidence of the excess or incremental costs of urinary tract infection (UTI) and pressure ulceration (PU) in acute traumatic SCI from an exploratory case series analysis of admissions to a Level I specialized Canadian spine facility (2008–2013) is presented. Participants in a national SCI registry were case-control matched (1:1) on the predicted probability of experiencing UTI or PU during initial acute SCI admission. The excess costs of UTI and PU are estimated as the mean of the differences in total direct acute SCI admission costs (length of stay, accommodation, nursing, pharmacy) from the perspective of the admitting facility between participants matched or paired on demographic and SCI characteristics. Even relatively minor UTI and PU, respectively, added an average of \$7,790 (standard deviation [SD] \$6,267) and \$18,758 (SD \$27,574) to the direct cost of acute SCI admission in 2013 Canadian dollars (CAD). This case series analysis established evidence of the excess costs of UTI and PU in acute SCI admissions, which will support decision-informing analyses in SCI.

Keywords: economic burden; pressure ulcers; secondary complications; spinal cord injury; urinary tract infections

Introduction

THE IMPAIRMENT AND DISABILITY resulting from acute spinal cord injury (SCI) has tremendous immediate and long-term consequences for injured persons, their family members, and the rest of society. Consequences include the perpetual risk of secondary complications because of the chronic health conditions caused by long-standing neurological deficits. Persons with SCI are susceptible particularly to complications such as urinary tract infection (UTI), pressure ulceration (PU), pneumonia, neuropathic pain, and thromboembolisms from the onset of SCI through the rest of their lives.^{1–12} In acute SCI populations, the reported incidence of secondary complications ranges from 44% to 77%,^{13–19} and the proportion of

individuals with a SCI ever experiencing a complication in their lifetime is reported to be as high as 95%.^{20–26}

Two of the more common secondary complications in acute SCI admissions are UTI and PU. In a population of acute traumatic SCI admissions to a Level I specialized spine facility in British Columbia, Canada, up to 43% of individuals experienced UTI²⁷ and 15% experienced PU.¹⁸ These reported incidences may suggest a demand for innovation in the prevention and management of hospital-acquired UTI and PU in the acute SCI population in Canada, but there is limited evidence to determine the extent of the demand.

Secondary complications of SCI, including UTI and PU, are believed to be a central determinant of health-related well-being and healthcare utilization beyond the initial consequences of SCI. The

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possible causes of UTI and PU, other than impaired mobility, sensation, and other physiological changes associated with SCI, are not fully understood. It is undeniable, however, that secondary complications of SCI during the initial hospital stay (hospital-acquired) or after discharge into the community (community-acquired) can increase the complexity of care and lead to significant human and economic costs. Complications in the acute phase of care may result in increased hospital length of stay (LOS), invasive or complex treatment(s), and predispose individuals to recurrence and development of further complications in the rehabilitation and community phases of care.^{16,18} After return to community-living, the consequences of complications may include excess use of ambulatory healthcare services, hospitalization, out-of-pocket expenses, lost employment earnings, limitations on activities of daily living, reductions in health-related quality of life, and in some cases death.^{2,10,18} Moreover, the value of forgone health benefits on account of the treatment and management of preventable secondary complications of SCI in all phases of care may represent significant opportunity costs.

Despite alarming rates of complications in SCI populations across the care continuum or over the lifetime of the individual^{16,18,19,28–33} and the impact on individuals and their family members, empirical evidence of the economic burden (or the potential cost avoidance associated with a reduction in the incidence and/or severity) of complications of SCI is limited. Of the two Canadian-based studies published more recently, one reported that the average excess cost of peri-operative adverse events or secondary complications after spinal surgical procedures ranged from less than \$5000 for grade 1 complications (least severe) to more than \$120,000 for grade 3 and 4 complications (most severe); the excess cost of particular acute SCI complications was not the primary focus of the analysis. The other study examined the cost of PU in a small number of individuals with SCI living in the community.³⁴ The average cost to manage community-acquired PU was estimated to be approximately \$4700 per month; however, the variability in monthly cost was found to be large, and limitations including the data collection period are believed to have resulted in conservative estimates.

Although evidence from alternative populations (e.g., SCI populations outside of Canada and general healthcare consumer populations in Canada) may lead to the establishment of reasonable assumptions for assessment of solutions to health problems in the Canadian SCI context, understanding of the problem in a particular context is believed to be important for appropriate assessment of the costs and consequences of relevant solutions. The existing evidence, on which assumptions will be based in the absence of further research involving SCI populations in Canada, has been established largely in general hospital or SCI populations in the United States. Because healthcare costs in Canada and the United States are different, existing evidence may not be generalizable to SCI populations in Canada.^{35–37} Further, existing evidence is limited in that it is commonly based on the association between hospital-acquired complications and hospital LOS, or community-acquired complications and the probability and duration of hospital readmission.

A recent review published by SCI Rehabilitation Evidence presents limitations in terms of evidence of the burden of SCI and the consequent paucity of high-quality comparative economic analyses of possible solutions to the burden of SCI.³⁸ Further evidence of the burden of secondary complications in SCI populations in Canada will enhance the breadth, quality, and relevancy of comparative economic analyses of solutions to the excess burden of secondary complications of SCI in the Canadian context. In turn, this information can enhance resource allocation decisions ultimately affecting the lives of persons living with SCI in Canada.

Although the context is believed to be important in assessing the costs and consequences of solutions, the establishment of an appropriate decision analytic or economic model in one context can inform important efforts in other contexts.

This article describes a retrospective case series analysis to establish evidence of the excess cost associated with two common secondary complications in acute traumatic SCI admissions in Canada—UTI and PU. This article does not present clinical or cost-effectiveness evidence; rather, it provides new information on the economic burden of UTI and PU to support decision-informing economic analyses and value for money considerations in SCI. Specifically, this work will support comparative economic analyses and decision analytic modeling in SCI.

Methods

Data compilation

Case series participants were selected from the Rick Hansen SCI Registry (RHSCIR), a prospective observational registry of adults with new traumatic SCI who were admitted to a participating Level I specialized spine facility in Vancouver, British Columbia, Canada (now referred to as the study site).³⁹ Local research ethics board approval was obtained before enrollment in the RHSCIR. Registry enrollment and privacy requirements are described elsewhere.^{39,40} The larger population of traumatic and non-traumatic SCI admissions to the study site during alternative periods along with respective incidences of common complications are also described elsewhere.^{18,19,29,31,32}

The case series was restricted to participants admitted to the study site within 48 h of injury to avoid potential confounders associated with delayed admission to specialized care, which has been shown to increase the risk of secondary complications.^{41,42} The case series was further restricted to participants age 19 and older at admission, because too few RHSCIR participants were age 16 to 18 to expect reasonable matches on demographic and SCI characteristics. Further details on the selection and arrangement of the case series analysis cohort are provided below.

The age at time of SCI (10 year age intervals), gender, neurologic classification at admission using the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) examination,⁴³ including American Spinal Injury Association (ASIA) Impairment Scale (AIS A, B, C, D), initial total motor score, neurological level (high cervical, C1–C4; low cervical, C5–T1; thoracic/thoracolumbar, T2–L2), neurology (complete, AIS A; incomplete, AIS B, C, D), and acute LOS were extracted from the RHSCIR. The RHSCIR also includes information on specific hospital-acquired complications (e.g., UTI and PU) recorded using the Spine Adverse Events Severity (SAVES)¹⁹ instrument for each participating acute SCI admission to the study site. The RHSCIR and the development and application of the validated SAVES instrument are described in detail elsewhere.^{19,39,44,45}

Case series analysis

Separate analyses were performed to examine the excess cost of UTI and PU in traumatic SCI admissions from the perspective of the study site. Like previous analyses of the excess cost of hospital-acquired complications,^{46–49} a matched case-control methodology was used to estimate the hospital cost associated with UTI and PU in admissions to the study site. The methodology and focus on UTI and PU were determined in consideration of the limited number of observations for which the study site agreed to provide basic costing information (a maximum of 50 participants) and to minimize the influence of confounding variables. The excess costs of UTI and PU are estimated as the mean of the differences in total direct acute SCI admission costs between matched or paired case series participants

who differed with regard to UTI or PU during acute SCI admission. Descriptive statistics were used to summarize the results. The small sample size prevented statistical analyses and subgroup analyses.

Analysis cohort

Before matching on observed demographic and SCI characteristics, four mutually exclusive groups of eligible RHSCIR participants were defined using the SAVES data:

- (1) UTI Group—experienced one or more UTI and no other documented complications.
- (2) No Complication Group—experienced no documented complications.
- (3) PU Group—experienced one or more PU.
- (4) No PU Group—did not experience a documented PU.

The matching process for the UTI cost analysis was limited to RHSCIR participants with no other secondary complications to avoid attributing the cost of other complications to the cost of UTI in acute SCI admissions. Participants assigned to the PU Group and No PU Group commonly experienced other documented complications during their acute hospital stay. Other secondary complications were considered in the matching process for the PU cost analysis, but not the UTI cost analysis.

After initial stratification (i.e., hard matching) by neurological AIS classification and neurology, eligible RHSCIR participants assigned to the UTI Group ($n=19$) were matched with participants assigned to the No Complication Group ($n=77$), and participants assigned to the PU Group ($n=22$) were matched with participants assigned to the No PU Group ($n=239$) based on propensity or predicted probability of experiencing UTI or PU, respectively. For the UTI and PU analyses, individual propensity scores were estimated using logit regressions conditional on age at time of SCI, gender, initial motor score, and neurological level in strata of sufficient size. As mentioned, incidence of other SAVES documented post-operative complications (i.e., UTI, pneumonia, delirium, one and two or more other complications) were also included in the estimation of PU propensity scores. A separate matching process was performed for individuals in the UTI Group and individuals in the PU Group. Logit regression estimation and 1:1 matching were performed using STATA 13 and the `psmatch2` command.⁵⁰

After identifying the individuals in the No Complication Group who best matched the 19 individuals in the UTI Group, and the individuals in the No PU Group who best matched the 22 individuals in the PU Group, the 25 pairs exhibiting the smallest difference in propensity scores were selected. The selected pairs included 10 participants in the UTI Group, 15 participants in the PU Group, and their respective best matches. Nearly all 25 selected pairs exhibited reasonable closeness based on the demographic and SCI characteristics included in the regression models.

The study site used an internal costing formula to calculate the direct cost of acute SCI admission for the agreed number of case series participants. The internal costing formula was based largely on acute LOS, documented transitions between hospital units, and respective unit daily cost assumptions (accommodation, nursing, and pharmacy) for 2013/2014 fiscal internal planning purposes. The results are presented in current (or unadjusted) 2013 CAD. For comparison, all other estimates discussed have been converted to 2013 CAD using Purchasing Power Parity and Statistics Canada's Consumer Price Index for Health and Personal Care.^{51,52}

Results

Analysis cohort

The case matching processes resulted in 10 and 15 pairs in terms of the predicted probability of UTI and PU, respectively. Two

pairs were excluded from the PU cost analysis, however, because the difference in the predicted probability of PU between pairs was considerably greater than the difference between the other pairs. Although there is no agreement on an acceptable difference in the propensity scores of matched participants,⁵³ the decision to exclude the two pairs exhibiting a propensity score difference of more than 0.20 was made to minimize confounding effects in the limited data and avoid overestimating the cost of PU. For these two pairs, differences in propensity scores appeared to be due to differences in experiences with other secondary complications. In addition, although the difference in propensity scores was reasonable, one pair was excluded because of data identified as extreme outliers (discussed further below). This left a total cohort of 44 participants, or 22 pairs, consisting of 10 pairs who differed with regard to development of hospital-acquired UTI, and 12 pairs who differed with regard to hospital-acquired PU.

The average age of the case series of 44 participants at time of SCI was 42 years; approximately 77% are male, 73% sustained a cervical SCI, and 55% had incomplete injuries at initial assessment. Demographic and SCI characteristics by group assignment are presented in Table 1. For the 20 participants included in the UTI cost analysis, the mean acute hospital LOS was estimated to be 18.4 days (standard deviation [SD] 8.1 days). The estimated average total direct cost of acute SCI admission for the 20 paired participants was \$19,171 (SD \$9171). For the 24 participants included in the PU cost analysis, the mean LOS was 41.4 days (SD 25.3 days), and the estimated average total direct cost was \$49,806 (SD \$32,723). Mean LOS and SCI admission cost by group assignment as well as the estimated mean of the differences in acute hospital LOS and costs between paired participants are presented in Table 2.

Hospital-acquired UTI

Exact or near exact matches, based on the stated criteria, were found for 10 participants assigned to the UTI Group. The difference between the 10 pairs from the UTI and No Complication Groups in the predicted probability of a hospital-acquired UTI was less than 0.01. The difference in LOS ranged from one to 16 days. The mean difference in acute hospital LOS between pairs in the UTI cost analysis was 6.8 days (SD 5.0 days; 95% confidence interval [CI] 3.2–10.4 days), and the mean difference in total acute SCI admission costs was \$7790 (SD \$6267; 95% CI \$3307–\$12,273) (Table 2). All UTI occurrence included in the cost analysis were described as complications necessitating minor noninvasive treatment with no long-term effects.

Hospital-acquired PU

The difference in the predicted probability of hospital-acquired PU was less than 0.02 for 11 of the selected pairs and 0.15 for the twelfth pair from the PU and No PU Groups, indicating reasonable matches on the characteristics included in the regression model. Hospital LOS ranged from 16 to 105 days in the PU Group and five to 70 days in the No PU Group. The difference in LOS between pairs ranged from 16 fewer to 59 additional days, and the mean difference was 15.8 days (SD 19.9 days; 95% CI 3.1–28.4). The mean difference in total acute SCI admission costs between paired participants in the PU cost analysis was \$18,758 (SD \$27,574; 95% CI \$1239–\$36,277) (Table 2). Although National Pressure Ulcer Advisory Panel (NPUAP) PU category data were not reviewed, the 12 paired participants in the PU Group experienced PU necessitating minor noninvasive treatment with no long-term effects, representative of less severe NPUAP category I or II PU.⁵⁴

TABLE 1. CHARACTERISTICS AND EXPERIENCES OF MATCHED OR PAIRED RICK HANSEN SPINAL CORD INJURY REGISTRY PARTICIPANTS ASSIGNED TO THE URINARY TRACT INFECTION, NO COMPLICATION, PRESSURE ULCERATION, AND NO PRESSURE ULCERATION GROUPS BY CASE SERIES GROUP ASSIGNMENT

	<i>UTI analysis</i>			<i>PU analysis</i>		
	<i>UTI (n = 10)</i>	<i>No Comp (n = 10)</i>	<i>d</i>	<i>PU (n = 12)</i>	<i>No PU (n = 12)</i>	<i>d</i>
Strict or hard matched characteristics						
ASIA Impairment Scale, %						
AIS A	30.0	30.0	0.00	58.3	58.3	0.00
AIS B	20.0	20.0	0.00	25.0	25.0	0.00
AIS C or D	50.0	50.0	0.00	16.7	16.7	0.00
Neurology of SCI, %						
Incomplete (AIS B, C, D)	70.0	70.0	0.00	41.7	41.7	0.00
Complete (AIS A)	30.0	30.0	0.00	58.3	58.3	0.00
Propensity score estimation characteristics						
Gender male, %	60.0	60.0	0.00	83.3	100.0	0.99
Age at time of SCI, mean (SD)	43.2 (22.7)	44.9 (15.4)	0.09	41.9 (18.4)	36.5 (21.3)	0.27
Initial motor score, mean (SD)	52.7 (15.9)	53.3 (20.3)	0.03	26.4 (26.6)	36.6 (28.4)	0.37
Neurological level, %						
High cervical (C1–C4)	30.0	30.0	0.00	25.0	25.0	0.00
Low cervical (C5–T1)	20.0	20.0	0.00	75.0	58.3	0.42
Thoracic/Thoracolumbar (T2–L2)	50.0	50.0	0.00	0.0	16.6	0.99
Other acute secondary complications, %						
UTI	N/A	N/A	N/A	66.7	75.0	0.22
Pneumonia	N/A	N/A	N/A	66.7	66.7	0.00
Delirium	N/A	N/A	N/A	16.7	8.3	0.43
1 other complication	N/A	N/A	N/A	33.3	33.3	0.00
2 or more other complications	N/A	N/A	N/A	50.0	41.7	0.19

UTI, urinary tract infection; PU, pressure ulceration; *d*, standardized mean-difference; ASIA, American Spinal Injury Association; SCI, spinal cord injury; SD, standard deviation; N/A, not applicable; No Comp, no complications.

Excluded outlying pair

As mentioned above, a pair was excluded from the PU cost analysis because the differences in LOS (221 days vs. 13 days) and SCI admission costs (\$226,714 vs. \$12,074) were identified as extreme outliers. The outlying pair was the only pair in which the PU was described as a complication necessitating invasive or complex treatment such as a surgical procedure or monitoring in the intensive care unit and, considering the limited number of pairs in the analysis, inclusion of the pair would have resulted in a near doubling of the cost of hospital-acquired PU in acute SCI admissions. Although it may be correct to assume that one in every 13 or so PU occurrence at the study site will require invasive or complex

treatment, data limitations prevented inclusion of the outlying pair. The implications are discussed, however, and help illustrate a limitation of the analysis as well as a fundamental consideration for economic and decision analytic modeling in SCI.

Discussion

The case series analysis established new evidence of the excess costs of hospital-acquired UTI and hospital-acquired PU in SCI admissions to the Level I specialized spine facility. The estimated excess cost of UTI requiring only minor noninvasive treatment in SCI admissions in the case series (\$7790) is relatively consistent with the reported excess cost of minor secondary complications

TABLE 2. SUMMARY OF ACUTE SPINAL CORD INJURY LENGTH OF STAY AND HOSPITAL COSTS FOR MATCHED OR PAIRED CASE SERIES PARTICIPANTS BY GROUP ASSIGNMENT AND ESTIMATED MEAN DIFFERENCES BETWEEN PAIRS

	<i>UTI analysis</i>			<i>PU analysis</i>		
	<i>UTI (n = 10)</i>	<i>No Comp (n = 10)</i>	<i>Combined (n = 20)</i>	<i>PU (n = 12)</i>	<i>No PU (n = 12)</i>	<i>Combined (n = 24)</i>
Total acute LOS, mean (SD)	21.8 (8.8)	15.0 (5.9)	18.4 (8.1)	49.3 (29.2)	33.5 (18.6)	41.4 (25.3)
Total hospital cost, mean (SD)	\$23,066 (\$10,155)	\$15,276 (\$5,940)	\$19,171 (\$9,030)	\$59,185 (\$38,112)	\$40,427 (\$24,382)	\$49,806 (\$32,723)
Estimated mean of differences						
LOS, mean (SD; 95% CI)	6.8 (5.0; 3.2 to 10.4)			15.8 (19.9; 3.1 to 28.4)		
Hospital cost; mean (SD; 95% CI)	\$7,790 (\$6,267; \$3,307 to \$12,273)			\$18,758 (\$27,574; \$1,239 to \$36,277)		

UTI, urinary tract infection; PU, pressure ulceration; LOS, length of stay in days; SD, standard deviation; CI, confidence interval.

accounting for 95% of UTI in a previous analysis of an acute SCI population in Ontario, Canada (\$6371).³⁰ The estimated cost of UTI in this case series is also within the range of costs attributed to minor hospital- and community-acquired genitourinary complications in general patient populations.^{55–57} In comparison, costs attributed to presumably more severe UTI in alternative patient populations are generally higher.^{2,16,48,58–64} The incremental cost of “clinically significant” hospital-acquired UTI in complex medical and surgical admissions in Ontario, Canada, for example, is reported to be \$23,667.⁴⁸ Similarly, in two Australia SCI populations, hospital-acquired UTI reportedly added \$24,569 and community-acquired UTI severe enough to result in hospitalization added \$16,354 to the average costs of care.^{16,64}

The range in reported costs of PU is even greater than the range in UTI. Average costs of PU in general inpatient populations range from \$2832 to \$54,062,^{46–48,56,57,59–61,65–87} and costs of PU in SCI populations range from \$18,533 to \$104,135.^{2,16,58,62,64,34,88–93} The range is expected to reflect demographic and geographic differences in the population being studied as well as associated differences in the severity of PU in the study population. The range may also reflect differences in the research or costing methodologies, observation period, products and services used to manage or treat PU, and duration of PU treatment. The excess cost of minor PU in the current case series (\$18,758) is consistent with the mean hospital cost of PU in a population of SCI admissions in Australia (\$18,533).¹⁶ It is not surprising that the result of the PU analysis is at the low end of the range in the reported average costs of PU in SCI populations, as, all else equal, the resources needed to manage a minor PU are expected to be less than the resources needed to treat a severe PU in an acute SCI admission and/or a PU severe enough to result in the hospitalization of a community-dwelling person with SCI.

In terms of the association between PU severity and cost, a recent cost analysis of hospital-acquired PU experienced by elderly patients in Ontario, Canada, revealed that NPUAP category II, III, and IV PU added on average \$43,782, \$68,090, and \$90,026 to hospital costs, respectively.⁸⁶ The importance of PU severity as a determinate of cost is echoed by analyses in alternative patient populations.^{48,68,71,87,94–99} Moreover, the cost to treat PU in any one person may differ significantly from the mean or expected cost of PU, as demonstrated by the range in per patient costs for PU resulting in hospitalization in Ontario, Canada (less than \$1500 to more than \$440,000),¹⁰⁰ and by a detailed case study of an individual with SCI in the United States describing PU-related costs of more than \$350,000.¹⁰¹

The exclusion or inclusion of a single individual with relatively severe PU has the potential to significantly affect the estimated average cost. In this analysis, inclusion of the excluded pair in which the PU was described as a complication necessitating invasive or complex treatment would have resulted in an 87% increase in the estimated average excess cost of PU (from \$18,758 to \$35,042). Exclusion limited the PU cost analysis to relatively minor complications; however, if the severity distribution in the initial series of paired participants experiencing PU during acute SCI admission (i.e., one hospital-acquired PU necessitating complex treatment for every 12 not requiring complex treatment) reflects the actual distribution of PU in the specialized spine facility, a more appropriate parameter for economic or decision analytic modeling may be closer to \$35,000. The possible consequences of using a parameter such as the expected cost of PU in a comparative economic model that does not consider the problem with respect to the population of interest and the severity of the problem extends beyond misinformed decisions concerning

the management of UTI and PU in acute SCI care. Therefore, the influence of severity on the cost of secondary complications including UTI and PU deserves further consideration.

Because the results of economic and decision analytic models depend on parameter inputs, it is essential that inputs such as the cost of UTI and PU across all phases in the SCI care continuum represent expected costs in the target population. Evidence from SCI populations suggests higher expected cost of PU presenting in the community phase of SCI care compared with the acute phase of SCI care.^{64,34} In an Australia SCI population, the average cost of hospitalization because of PU within two years of SCI is estimated to be \$25,994.⁶⁴ Similarly, the average cost attributed to PU in a population of community-dwelling individuals with SCI in Ontario, Canada, is estimated to be \$4797 per month or \$57,564 over a conservative seven month recording period.³⁴ In a U.S. population of community-dwelling persons with SCI served by the Veterans Health Administration, the estimated excess cost of PU over a 12 month observation period is nearly \$80,000.⁹³

The variation in existing estimates of the cost of secondary complications of SCI across the care continuum may be explained by a trend in the expected cost of complications in patients presenting at different time points in the SCI care continuum along which distributional discrepancies in the severity of hospital- and community-acquired complications exist. Therefore, in modeling the economic costs and consequences of possible solutions to the burden of UTI, PU, or other secondary complications, the distinction between hospital- and community-acquired complications and/or the severity distribution and associated risk factors are important considerations for the assessment and comparison of solutions to the burden at different points in the SCI care continuum.

Implications

Although the evidence is limited, what is known about the burden of UTI and PU suggests a need and opportunity for innovation in the prevention and management of secondary complications across the SCI care continuum. Because of the small number of observations, statistical significance was not assessed in the case series; however, the excess costs of UTI (\$7790) and PU (\$18,758) are considerable in comparison to the estimated mean acute SCI admission costs for the No Complication Group (\$15,276) and the No PU Group (\$40,427), representing an addition of 51% and 46% to acute admission costs, respectively.

Having evidence of the average cost of a particular secondary complication alone is not sufficient to help decision makers decide what to do about the problem. In-depth assessment of the extent of the problem in acute SCI admissions, which would include factors such as the size of the target population, the influence of acute complication experiences on the risk of subsequent complications, and the cost of possible solutions is necessary to support consideration of relevant solutions. As a simple example, if one assumes that 20 in every 100 acute SCI admissions will experience PU costing approximately \$19,000, the expected cost for 100 admissions would be \$380,000. If an intervention that prevented 50% of PU occurrences could be offered at a cost of \$1900 per person, it may be justified from a narrow perspective. Further effort to determine the burden (human and economic cost) of complications in the SCI acute, rehabilitation, and community phase of care, as well as the effectiveness of possible solutions, however, is necessary to better inform the supply of solutions across the continuum of SCI care.

Limitations

Although case series participants were selected from a larger population of consecutive admissions to the study site, the case series population is not necessarily representative of the larger acute SCI population or the SCI population experiencing acute complications. For reasons discussed, the UTI cost analysis was limited to participants with no other documented acute complications. The results of the UTI and PU cost analyses reflect the excess hospital cost of relatively minor UTI and PU in acute traumatic SCI admissions to a specialized spine facility, which may limit generalizability to alternative populations. Our results, however, are within the range of earlier analyses, adding increased confidence to the generalizability of evidence established in alternative general patient and SCI populations.

The assumption is that documented UTI and PU led to excess days in hospital; but given that the time of complication onset was not considered, it is possible that unobserved factors led to the extended LOS, which may have led to documented secondary complications. In addition, because matching was based on a limited number of observed demographic and SCI characteristics, the estimated excess cost of UTI and PU may reflect unobserved factors. Another notable limitation is that the cases series was restricted to participants with relatively minor UTI and PU, and stratification by UTI and PU severity was not possible. In general, the case series sample size restriction prevented other important subgroup analyses, added to the variability in terms of the difference in estimated acute SCI hospital cost between pairs, and increased the influence that a single difference may have on the estimated mean of the differences.

Although this analysis made effective use of the limited costing information provided by the study site, the matched-case control methodology employed has certain limitations.¹⁰² In particular, the results are only as good as the matches or the matching criteria. Although the available data were not appropriate in this case series, activity-based or bottom-up cost analyses that require a review of sufficiently detailed resource utilization or costing information and subsequent determination of relevant resources or expenditures at the participant level may have certain advantages. One advantage may be the avoidance of bias in cost estimation due to matching on a limited number of observed characteristics, however, the choice of methodology depends on the data available.

The exclusion of other costs to affected individuals, their family members, and healthcare systems is a limitation that is expected to have contributed to the conservative nature of the results. With respect to the acute hospital cost data that were available, the study site does not maintain a case-costing system, and the basic costing formula applied by hospital financial planning and business support is expected to have resulted in conservative estimates of the total acute SCI admission costs. Because the costing formula was applied to selected participants with and without UTI and PU for the respective cost analyses, however, the effect of the basic formula on the estimated excess burden of UTI and PU is unclear.

Next steps

The Access to Care and Timing (ACT) simulation model for SCI care,^{103,104} described in the current focus issue,¹⁰⁵ is one example of a decision analytic model that allows for comparative analyses of interventions in one phase of care on the entire continuum of care. The results of the case series and discussion will support application of the ACT model to access possible solutions to the burden of UTI and PU in the traumatic SCI population. The presentation of results will also support the evaluation of the benefits and costs of alternative solutions more broadly.

As per the Rick Hansen Institute's Health Economics Agenda for SCI Research in Canada,¹⁰⁶ however, evidence of the burden of secondary complications of SCI and knowledge of the structural relationship between the burden and possible solutions to the burden at different points in the SCI care continuum are necessary to ensure possible solutions receive due consideration. Further consideration of the collection, organization, and provision of costing and resource utilization information across the SCI continuum of care will continue to support the establishment of evidence or appropriate inputs for decision analytic modeling and comparative economics analyses.

In the development of a whole system model to better inform clinical practice and resource allocation decisions ultimately affecting people sustaining a SCI in Canada, further estimation and consideration of the human and economic costs associated with common secondary complications beyond the acute phase and across the SCI care continuum are critical. The lessons learned through this exploratory case series analysis in terms of the limitations of costing information available through the study site for cost analysis in the acute SCI population will inform necessary next steps.

Conclusion

The case series analysis provided conservative estimates of the excess or incremental costs of UTI and PU in SCI admissions to a Level I specialized spine facility, establishing evidence needed to enhance the breadth, quality, and relevancy of information from future economic analyses and decision analytic modeling efforts in SCI. Further understanding of the burden of secondary complications of SCI across the continuum of care, as well as the alternative solutions will encourage the establishment of comparative economic evidence to better inform clinical practice and health policy decisions involving such risk versus reward and value for money considerations in SCI in Canada and beyond.

Acknowledgments

The authors thank the Vancouver Spine Research Program (Juliet Batke, Allan Aludino); the Rick Hansen Institute RHSCIR Team (Suzanne Humphreys, Daniel Rogers, Kristen Walden, Jayson Shurgold, Jessica Eapen, Jerome Buenaventura, Tova Plashkes, Arlene Aspinall, Cynthia Morin, and Shannon Sproule); all members of the Vancouver Spine Surgery Institute; and the Vancouver Coastal Health, Financial Planning and Business Support for their contribution to the study.

This study was supported by financial contributions from the Rick Hansen Institute, the Ontario Neurotrauma Foundation, and the Government of Canada through Health Canada and Western Economic Diversification Canada.

Author Disclosure Statement

No competing financial interests exist.

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