Costs of Care Following Spinal Cord Injury

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The purpose of this study was to develop new estimates of the costs of care following spinal cord injury in the United States. Information from the National Spinal Cord Injury Statistical Center database was supplemented where necessary with estimates from a previous comprehensive study of lifetime costs updated for inflation to 2009 US dollars. Overall mean first-year charges were $523,089. Mean annual charges over the remainder of life were $79,759. Charges varied substantially by injury severity. These estimates are considerably higher than the inflation-adjusted estimates from our previous study. **Key words:** *cost of care, epidemiology, spinal cord injury*

Although spinal cord injury (SCI) does not occur as often as many other types of injuries and debilitating diseases, its costs to both individuals and society are staggering.[1-5] Moreover, with advancing medical technology and improving acute survival rates,[6,7] the direct costs of SCI are increasing at a rapid pace. Information on average lifetime costs to individuals is extremely valuable to persons with SCI, life care planners, case managers, lawyers, and insurance companies, who must ensure that adequate resources are set aside to meet the needs of individuals with SCI over the remainder of their lifetimes. Health economists can also use this information in cost-benefit analyses of clinical and preventive interventions.

The National SCI Statistical Center (NSCISC) database of persons treated at federally designated SCI Model Care systems initially included many variables aimed at documenting both initial and long-term direct costs for persons with SCI.[8,9] These variables included days hospitalized and rehospitalized along with associated charges; days spent in nursing homes and associated charges; and charges for emergency medical services, physician services, equipment, environmental modifications, attendant care, outpatient therapy, medications, supplies, and vocational rehabilitation. Results of this early data collection activity were published in 1982.[10]

Hospital charges reflect the hospital's retail price for covered and noncovered services from the hospital's "chargemaster." The charges typically do not include physician fees. Conversely, the cost of care reflects an estimate of the hospital's actual cost of providing care. Cost estimates were never part of the NSCISC database.

It is not surprising that information on charges for provided services proved extremely difficult, time consuming, and expensive to collect on a routine basis. As a result, starting in 1983, these data are no longer collected as part of the NSCISC data set. By 2000, the only remaining items in the NSCISC database related to costs of care were acute care, rehabilitation, rehospitalization, nursing home lengths of stay, hours of attendant care per day, and hours of outpatient therapy services. Moreover, the only remaining information on charges was for initial acute care and rehabilitation.

To fill this void, 3 comprehensive cost studies were initiated in the late 1980s and early 1990s. Building on their previous work, as well as that of others, Berkowitz and colleagues published the results of a detailed investigation of the economic consequences of SCI.[1,2] At the same

Top Spinal Cord Inj Rehabil 2011;16(4):1–9

www.thomasland.com

doi: 10.1310/sci1604-1

time, 2 collaborative studies of the long-term costs of SCI incurred by persons initially treated at model systems were undertaken by DeVivo et al and Whiteneck.[3-5] Each of these studies amassed extensive cost data from several hundred persons with SCI. The study by Berkowitz et al utilized a population-based sample augmented by persons from membership lists of organizations representing the disabled SCI population, from independent living centers, and from referrals by persons already in the study.[1,2] DeVivo et al's model system study included a random sample of persons from the NSCISC database,[3,4] while Whiteneck's study involved persons treated at any of 3 model systems.[5] Berkowitz et al used standard cost estimates for each service, whereas the model system studies used actual charges incurred by the study participant. Results of each study were reasonably consistent.

Following publication of these studies in the early 1990s, the NSCISC has published, on an annual basis, revised estimates of lifetime costs based solely on updating its original study for inflation and without consideration of any changes in treatment that may have occurred.[3,11] In addition to being outdated, the main limitation of all of the model system and Berkowitz studies is that they do not take into account the needs of persons with SCI; long-term costs were based on goods and services actually received and thus these studies underestimated the costs of optimal care.

Although there have not been any comprehensive studies of lifetime costs of care for persons with SCI since the early 1990s, several studies have been undertaken to investigate either specific SCI subpopulations or specific categories of either short-term or long-term costs. Johnson et al conducted a population-based study of costs during the first 2 years after SCI.[12] In addition to calculating total charges, they also determined the average charges associated with different types of medical complications, with charges in 1992 dollars ranging from $22,321 for neurological complications to $233 for pain.

Two companion studies evaluated the services provided to a group of 62 persons with work-related tetraplegia and costs of those services in 2000 dollars.[13,14] First-year costs were similar to those from the model systems study after adjustment for inflation while annual costs thereafter were higher, suggesting that long-term costs were rising faster than inflation.[3]

Using model system data, Fiedler et al demonstrated that combined charges for inpatient acute care and rehabilitation in constant 1997 dollars rose from $836 per day in 1973 to $2,791 by 1997.[15] Despite declining average length of stay, acute care inpatient charges in constant 1997 dollars rose from $34,072 in 1973 to $115,018 in 1994 before declining slightly thereafter. Similarly but not as dramatically, inpatient rehabilitation charges in constant 1997 dollars rose from $96,798 in 1973 to $119,510 in 1991 before declining thereafter. Again, this increase occurred despite substantially declining rehabilitation lengths of stay.

More recently, separate estimates of trends in acute care and rehabilitation charges per day in constant 2005 dollars were produced from the NSCISC database, indicating that most of the increase in inflation-adjusted charges occurred during acute care rather than rehabilitation.[16] Acute care charges per day rose from $2,613 during 1973-1981 to $11,444 during 2002-2006, while rehabilitation charges per day increased from $1,380 to $2,471 over the same time period.

Costs of care have also been estimated for persons with SCI treated in Alberta, Canada.[17] Attributable costs in the first year after injury were $121,600 (2002 Can$) per person with a complete SCI, and $42,100 per person with an incomplete SCI. In the subsequent 5 years, annual costs were $5,400 and $2,800 for persons with complete and incomplete SCI, respectively.

There have also been 2 recent investigations of costs of SCI care in the Veterans Administration (VA) health care system.[18,19] In the first study, among non-ventilator-dependent wheelchair users with SCI who were at least 2 years post injury, annual total costs per patient for services provided by the VA in 2005 dollars were $21,450, and ranged from $28,334 for persons with complete cervical injuries to $16,792 for persons with incomplete thoracic injuries.[18] The second study focused on costs of VA services provided in the final 2 years of life.[19] Excluding pharmacy costs, that study found average costs of $61,900 in the last year of life and $24,900 in the next to last year of life. It is important to note, however, that both these studies were limited to the costs of services provided by the VA. Thus, they do not include the cost of attendant care, which other studies have shown is the single biggest long-term cost item for persons with SCI. Conversely, those studies did not seem to include individuals who were healthy and did not receive any services, thereby possibly overstating average costs per person.

Ventilator-dependent persons have been shown to have particularly high costs of long-term care. In 1997, Botel et al estimated annual postdischarge costs of $357,386 plus first-year equipment charges of $116,542.[20] The latter charges would not occur every year but only when equipment needed to be replaced. Similarly, in 1992 dollars, ventilator-dependent persons treated at model systems averaged $236,944 per year after the first postinjury year.[3]

An important but unexplored issue is how the expense and intensity of treatment affects survival for persons with SCI. The general economic literature on health care finds that acute hospital survival across all types of admissions can be enhanced with greater resource use.[21]

A new comprehensive study of costs of care for persons with SCI is long overdue. Therefore, the purpose of this study was to provide a new estimate of initial and long-term costs of care for persons with SCI based on new information contained in the NSCISC database when available and updates of the prior NSCISC database study for inflation when necessary.

Method

Original study

In the original study, direct costs were defined as charges incurred by either persons with SCI or their responsible third parties that were the direct result of the injury. To the extent possible, charges pertaining to medical conditions that were not directly related to SCI were not included. No attempt was made to determine the amounts of charges that were actually reimbursed or the proportion of charges that constituted actual out-of-pocket expenses for the person with SCI.

The study population included a random sample of 508 persons originally treated between 1973 and 1988 at a model system and enrolled in the NSCISC database. A complete description of the database, its history, eligibility criteria, contents, and data quality appears elsewhere.[8,9] A 1-year cross-section of data was collected prospectively between 1989 and 1990. These data included all charges incurred during the year as a direct result of the injury. Initial data collection was by periodic telephone interviews and diaries kept by study subjects. In most instances, charges were verified by either the provider or the third-party payer. Shadow pricing was used in instances when free items or services were provided to estimate and include their fair-market value in the cost analysis. All NSCISC database information was also collected at this time.

In addition, 227 newly injured persons were randomly enrolled in 1989 or 1990 to assess, prospectively, the unique expenses for emergency medical services, acute care, and rehabilitation that occurred during the first year after injury. Data collection methods were identical to those used to document charges after the first postinjury year. Therefore, the total study population was 735 persons. A complete description of the original study methodology and results was published in 1995.[3]

Current study

New estimates of several categories of costs were developed based on the most recent data from the NSCISC database. Initial acute care lengths of stay and charges were based on the experiences of all persons admitted to a model system within 24 hours of injury between 2000 and 2006 (n = 1,676) who had complete data on these items (n = 1,508). Inpatient acute care hospital charges reflect the amounts billed to patients or third parties and typically do not include physician fees. Inpatient acute care costs were based on applying the cost to charge ratios for each model system acute care facility to the charge data.[22] Costs were adjusted to 2009 dollars using the hospital services of the Consumer Price Index (CPI).

Inpatient rehabilitation lengths of stay and charges were based on the experiences of all persons admitted to a model system within 24 hours of injury between 2000 and 2006 (n = 1,676) who received inpatient rehabilitation at the model system and had complete data on these items (n = 1,599). Once again, charges reflect amounts billed and typically do not include physician fees. Inpatient rehabilitation costs were based on applying the cost to charge ratios for each model system rehabilitation facility to the charge data.[22] Costs were adjusted to 2009 dollars using the hospital services of the CPI.

Attendant care hours per day, days in a nursing home, and days rehospitalized for secondary medical conditions or follow-up rehabilitation were based on self-report of all persons in the NSCISC database who completed an annual follow-up evaluation between 2000 and 2006 and had complete data on this item (n = 7,637 for attendant care, n = 8,239 for nursing home days, and n = 8,034 for days rehospitalized). When 2 or more annual evaluations were completed, the most recent was used. These annual follow-up evaluations ranged from 1 year after injury to 30 years after injury. Attendant care included both paid and unpaid services.

The cost of each hour of attendant care per day (whether paid or unpaid) was based on the national average cost of a home health aide in 2009 ($21 per hour).[23] This estimate was based on a national survey of home care agencies and reflected their private pay rate rather than their Medicare or Medicaid reimbursed rate. The cost of each day in a nursing home was based on the national average cost of a semi-private room in 2009 ($198 per day).[23]

The cost of each day hospitalized was based on the results of the study by DeVivo and Farris appearing elsewhere in this issue of *Topics in Spinal Cord Injury Rehabilitation*.[24] Briefly, a total of 430 rehospitalizations occurring among patients whose initial rehabilitation occurred at the University of Alabama at Birmingham (UAB) were identified. Billing records were obtained from each hospital as well as from Alabama Medicaid computer listings where appropriate. Approximately 50% of the rehospitalizations occurred at UAB and the remaining 50% occurred at other hospitals. Estimation of hospital costs was based on case-weighted statewide average cost to charge ratios for urban and rural hospitals in the state where the hospitalization occurred.

The NSCISC database does not contain any new information on any of the other cost categories in the original study, including emergency medical services, outpatient services and physician fees, medications, supplies, vocational rehabilitation, environmental modifications, durable equipment, and other miscellaneous costs. Therefore, the costs for these categories that were estimated in the original study in 1992 dollars were adjusted for inflation to 2009 dollars using the CPI for all items.

Statistical analysis

Results were stratified into 4 neurologic categories consistent with the presentation of results in the original study. The 4 categories were as follows: C1-4 with American Spinal Injury Association Impairment Scale (AIS) A, B, or C; C5-8 with AIS A, B, or C; T1-S5 with AIS A, B, or C; and AIS D at any level. All ventilator-dependent persons were grouped in the C1-4 with AIS A, B, or C group regardless of injury level or AIS grade. Injury level and AIS grade were determined in accordance with the International Standards for Neurological Classification of Spinal Cord Injury.[25] Results were also stratified by time post injury, with separate results for the first year after injury. Results for all other years were combined when no significant differences were found. All results are presented as means for each cost category for each group.

Results

Mean inpatient lengths of stay, charges, and costs appear in **Table 1**. Mean acute care charges range from $505,029 (*SD* $734,976) for the C1-4 group to $170,915 (*SD* $158,443) for the AIS D group, while corresponding costs range from $143,359 (*SD* $271,308) to $45,155 (*SD* $43,949) for the same groups. Mean rehabilitation charges range from $286,249 (*SD* $241,059) for the C1-4 group to $98,405 (*SD* $105,791) for the AIS D group, while corresponding costs range from $132,758 (*SD* $129,335) to $40,033 (*SD* $49,663) for the same

Table 1. Mean hospitalization lengths of stay, charges, and costs by neurologic category (2009 US dollars)

Cost category	C1-4 ABC	C5-8 ABC	T1-S5 ABC	AIS D	All groups
Acute care/rehabilitation sample size	203	334	606	533	1,676
Initial acute care days	32.3	25.4	18.2	12.6	19.4
Initial acute care charges	505,029	361,030	256,992	170,915	278,161
Initial acute care costs	143,359	100,079	71,083	45,155	76,711
Rehabilitation days	76.1	63.1	43.6	32.0	47.7
Rehabilitation charges	286,250	215,301	133,300	98,405	157,151
Rehabilitation costs	132,758	93,201	58,410	40,034	68,543
Rehospitalization sample size	1,100	1,929	3,219	1,786	8,034
Rehospitalizations days each year	7.7	6.3	6.4	2.2	5.6
Rehospitalization charges per year	30,975	25,333	25,533	8,764	22,531
Rehospitalization costs each year	15,929	13,027	13,130	4,507	11,587

Note: AIS = American Spinal Injury Association Impairment Scale.

groups. The mean charges for rehospitalizations each year ranged from $30,975 for the C1-4 group to $8,764 for the AIS D group, while mean costs of rehospitalizations for the same groups were $15,929 and $4,507.

Table 2 includes all other charges incurred following rehabilitation discharge during the remainder of the first postinjury year. Regardless of injury severity, charges are highest for attendant care. Equipment charges rank second for the C1-4 and C5-8 groups, while environmental modifications rank second for the T1-S5 group and outpatient services rank second for the AIS D group. Mean charges for other categories range from a few hundred to a few thousand dollars each.

Recurring annual charges after the first postinjury year appear in **Table 3**. Once again, attendant care is the most costly item for all neurologic categories. Equipment purchases rank second for the C1-4 and C5-8 groups, while supplies rank second for the T1-S5 group and nursing home care ranks second for the AIS D group. Mean charges for other categories range from less than $100 dollars to just over $2,000.

Mean total charges and costs for the first year after injury and each year thereafter appear in

Table 2. Mean charges during the first year after injury by neurologic category (2009 US dollars)

Cost category	C1-4 ABC	C5-8 ABC	T1-S5 ABC	AIS D	All Groups
Sample size	26	50	73	78	227
Emergency medical services	1,879	1,489	1,517	1,239	1,457
Nursing home[a]	3,968	2,109	1,103	1,180	1,750
Outpatient services	5,294	4,414	3,913	4,015	4,217
Physician fees	959	706	838	783	804
Equipment	21,667	15,717	5,368	2,745	8,613
Environmental modifications	12,214	11,572	9,442	465	7,144
Medications	2,101	1,872	1,356	726	1,338
Supplies	1,809	1,865	2,003	505	1,436
Attendant care[b]	79,527	46,729	21,168	20,631	37,192
Vocational rehabilitation	1,341	232	891	240	573
Miscellaneous	347	517	1,209	528	722

Note: AIS = American Spinal Injury Association Impairment Scale.

[a]Sample sizes for nursing home costs: C1-4 = 1,117; C5-8 = 1,976; T1-S5 = 3,325; AIS D = 1,821.

[b]Sample sizes for attendant care costs: C1-4 = 1,031; C5-8 = 1,837; T1-S5 = 3,053; AIS D = 1,716.

Table 3. Mean annual charges beginning in the second year after injury by neurologic category (2009 US dollars)

Cost category	C1-4 ABC	C5-8 ABC	T1-S5 ABC	AIS D	All groups
Sample size	55	131	200	122	508
Nursing home[a]	3,968	2,109	1,103	1,180	1,750
Outpatient services	3,099	1,786	1,390	979	1,578
Physician fees	563	613	508	306	492
Equipment	5,231	2,538	1,731	743	2,081
Environmental modifications	942	1,602	1,705	89	1,208
Medications	2,243	2,130	1,356	888	1,540
Supplies	2,379	2,306	2,002	836	1,841
Attendant care[b]	114,515	61,780	25,524	23,608	45,837
Vocational rehabilitation	624	644	281	150	381
Miscellaneous	1,015	719	417	249	520

Note: AIS = American Spinal Injury Association Impairment Scale.

[a]Sample sizes for nursing home costs: C1-4 = 1,117; C5-8 = 1,976; T1-S5 = 3,325; AIS D = 1,821.

[b]Sample sizes for attendant care costs: C1-4 = 1,031; C5-8 = 1,837; T1-S5 = 3,053; AIS D = 1,716.

Table 4. Mean total charges and costs by neurologic category (2009 US dollars)

Cost category	C1-4 ABC	C5-8 ABC	T1-S5 ABC	AIS D	All groups
First-year charges	953,360	688,886	464,633	311,141	523,089
First-year costs	423,152	293,529	191,431	122,753	222,087
Annual charges after year 1	165,554	101,560	61,550	37,792	79,759
Annual costs after year 1	150,508	89,254	49,147	33,535	68,815

Note: AIS = American Spinal Injury Association Impairment Scale.

Table 4. Total charges in the first year reflect all charge items in **Table 1** plus all items in **Table 2**, whereas total charges in subsequent years reflect the rehospitalization charges in **Table 1** plus all items in **Table 3**. Total costs are calculated similarly, but substitute costs for charges from **Table 1**. Overall, mean first-year charges range from $953,360 for the C1-4 group to $311,141 for the AIS D group. These figures are considerably lower when costs are substituted for charges for inpatient categories. Mean recurring annual charges range from $165,554 for the C1-4 group to $37,792 for the AIS D group. Mean costs each year are only marginally lower than charges.

A comparison of comparable categories for recurring annual charges between the present study and the only other comprehensive study of lifetime costs by Berkowitz et al adjusted for inflation to 2009 dollars appears in **Table 5**.[2] Because the 2 studies used different methods to group patients by neurologic status, only the comparison of overall average charges by category is shown.

Results are almost identical for the 2 studies except for attendant care and rehospitalizations. Attendant care costs appear to have been substantially underestimated in the Berkowitz study. This difference is due in part to a difference in average hours of attendant care per day (6 in the present study and 4 in the Berkowitz study) and in part to the low hourly cost of attendant care that was used in the Berkowitz study ($7.91 per hour in 1996 dollars, or $12.09 per hour in 2009 dollars). For rehospitalizations, the Berkowitz study used diagnosis-related groups (DRGs), whereas the current study uses actual charges and cost to

Table 5. Comparison of mean recurring annual charges adjusted to 2009 US dollars by expense category

Category	Present study	Berkowitz et al[2]
Attendant care	45,837	15,679
Environmental modifications	1,208	1,295
Medications	1,540	1,556
Supplies	1,841	1,848
Rehospitalizations[a]	22,531	16,153
Equipment	2,081	1,786

[a]The estimate of cost of rehospitalizations from the present study was $11,587.

charge ratios. As a result, the Berkowitz estimate for rehospitalizations is between the current study estimates for charges and costs.

Discussion

This study reaffirms the extraordinarily high costs associated with SCI. It provides new and improved estimates based on new data for inpatient care, attendant care, and nursing home care. Inpatient care and attendant care are by far the 2 largest categories of long-term care costs. Moreover, inpatient care has changed substantially over the past 2 decades, lengths of stay have been reduced, particularly for rehabilitation, and inpatient care costs have been subject to a higher rate of inflation than other cost categories. Therefore, inpatient care was perhaps the cost category in greatest need of new data.

Although acute care length of stay has decreased in recent years, average charges per day in inflation-adjusted dollars have skyrocketed.[14] As a result, it is not surprising that the new estimate of mean acute care charges provided by this study ($278,161) is substantially higher than the estimate of mean inflation-adjusted acute care charges from our previous study ($94,690).[3] Moreover, given that most rehospitalizations are for acute medical complications such as pneumonia, pressure ulcers, and septicemia, it is not surprising that the new estimate of mean rehospitalization charges per year ($22,531) is much higher than the estimate of mean inflation-adjusted rehospitalization charges from our previous study ($7,361).[3]

Rehabilitation charges per day in constant inflation-adjusted dollars have also increased over time, but not as much as acute care charges per day.[14] As a result, the new estimate of mean rehabilitation charges provided by this study ($157,151) is also higher than the estimate of mean inflation-adjusted rehabilitation charges from our previous study ($134,203).[3]

The new estimate of mean annual attendant care costs ($45,837) is also significantly higher than the inflation-adjusted estimate of mean annual attendant care costs from our previous study ($17,505). This could be the result of increased usage of attendant care, but data on hours of attendant care used per day were not provided in our previous study. However, most of the difference results from a methodological change in the way unpaid attendant care costs were estimated in this study. In our previous study, unpaid attendant care was priced at the value of an unskilled worker, and some individuals hired independent attendants rather than using home health agencies that typically charge more due to overhead costs. However, in the present study, paid and unpaid attendant care were both priced at the cost of a private pay home health aide hired through an agency ($21 per hour). Therefore, the current method better reflects what the attendant care provided by unpaid family members would cost if purchased from outside providers.

Given that all newly estimated cost categories exceed the inflation-adjusted estimates from our previous study, it is not surprising that both the estimates of mean total first year and mean total annual charges exceed the comparable inflation-adjusted estimates from our previous study by considerable amounts. Nonetheless, these estimates must be considered as conservative given the study limitations described in the next section.

Limitations

This study has several important limitations. First, the study sample is not population-based, and persons treated at model systems may not be representative of the total SCI population in terms of the costs of their care, even after stratifying results by injury severity.

The second limitation is that no new information was available for many cost categories such as medications, equipment, supplies, environmental modifications, vocational rehabilitation, and physician fees. In particular, costs associated with new medications or equipment that first became available after the original study was conducted in 1992 could not be included in this updated study. Conversely, some brand name medications might now be available in less costly generic form. In any event, these cost categories that were only updated for inflation are not the categories associated with the greatest expenses, and small errors in their estimated costs will not greatly impact overall results.

Another limitation is that this study was not based on either an assessment of the specific needs of each person or the provision of optimal care. Instead, it was based on the actual goods and services that were received by each person. Although some persons might by choice have received more care than was actually necessary, it is more likely that some persons were not receiving goods or services that would be beneficial due to financial or insurance limitations. Therefore, the results of this study are likely to underestimate the costs of care under optimal conditions.

It is also important to distinguish between costs and charges. The original study was based on charges, so those categories based on updates of the original study solely for inflation are still based on charges. However, in the present study, for categories of expenses where new information was available, costs were estimated based on cost to charge ratios or insurance reimbursement rates.

Finally, the results are expressed in terms of average costs. Actual costs for any individual will vary substantially based on local differences in the price of goods and services within the community where the person resides. Another source of substantial variation in cost would be whether attendant care is purchased through an agency with significant overhead costs or directly from the individual providing the service at a somewhat reduced price.

Conclusion

This study provides new estimates of first year and annual charges and costs following SCI. Overall, mean first-year charges are $523,089 while mean annual recurring charges are $79,759. These estimates are likely to be conservative. They can be useful in cost-benefit analyses of new interventions and prevention programs. Such items as average rehospitalization charges might also be useful to life care planners when trying to estimate potential future medical expenses for their clients. However, the overall estimates of charges and costs cannot substitute for a professionally developed life care plan based on the actual needs of the individual and the costs of providing those needed services in the community where the individual resides.

Acknowledgment

This work was supported in part by grant H133A060039 from the National Institute on Disability and Rehabilitation Research (NIDDR), Office of Special Education and Rehabilitation Services, US Department of Education, Washington DC, and in part by funding from InVivo Therapeutics.

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Lifetime Direct Costs After Spinal Cord Injury

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Applying the latest data from the National Spinal Cord Injury Statistical Center, we update the average lifetime direct costs of spinal cord injury (SCI) in the United States. Assuming that health care price inflation equals future interest rates, the lifetime direct costs for persons injured at age 25 vary by severity of injury, ranging from 2.1 to 5.4 million dollars, which are much higher than what has been expected based on inflation-adjusted data from 1992. This increase is attributable to both the improvement in life expectancy in the SCI population and an increase in costs of care after SCI. **Key words:** *health care costs, life expectancy, spinal cord injury*

Advances in medical practice have brought about dramatic improvements in survival after spinal cord injury (SCI) in the past half century.[1-3] Knowledge of the secular trends in life expectancy following SCI is important not only because they are markers for changing morbidity and mortality in the SCI population, but also because they are the primary determinants of the allocation of resources for care through the lifetime of persons with SCI. Traumatic SCI typically happens to males in their 20s and 30s[4-6] and is mostly associated with a high-level permanent disability. As a result, SCI could be a heavy burden to affected individuals, their families, and society, even though the incidence of SCI is relatively low as compared with other types of injuries or major debilitating diseases.

Despite the fact that none of the existing methods for estimating lifetime costs is perfect, there have been several attempts in the past. The National Spinal Cord Injury Statistical Center (NSCISC) database contains data from patients with SCI who received initial hospital care at one of the SCI Model Systems, which is believed to capture 10% to 15% of persons with traumatic SCI in the United States. DeVivo and colleagues[7] utilized a random sample from the NSCISC database and estimated that the average lifetime direct costs (in 1992 US dollars) for an individual injured at age 25 were 1.3 million for C1-4 injuries, 0.8 million for C5-8 injuries, 0.4 million for T1-S5 injuries, and 0.3 million for motor functional incomplete injuries (American Spinal Injury Association Impairment Scale [AIS] D) regardless of injury level, assuming a 4% net rate of return on investments above inflation. For an individual who had SCI at age 50, the lifetime direct costs were 0.9 million, 0.5 million, 0.3 million, and 0.2 million for the same groups.

Using a population-based sample, Berkowitz and colleagues[8] estimated that the lifetime direct costs (in 1996 US dollars), with the same 4% discount rate, were 0.9 million for persons injured at age 37 with tetraplegia, 0.5 million for those injured at age 31 with paraplegia, and 0.3 million for those injured at age 40 with AIS D. It is difficult to compare Berkowitz's estimation with DeVivo's because of different sources of data, age groups, and neurologic categories. However, both studies are comprehensive and provide a range of estimation for lifetime direct costs following traumatic SCI in the 1990s.

There have been advances in medical and rehabiliation care, health services and delivery, and technology since these 2 studies were completed. While some argue that costs of care following SCI might be lower than before because of a shorter length of stay in acute care and rehabilitation,[9] others suggest that the costs have increased significantly over the last decades.[10, 11] There are recent studies investigating long-term cost in the SCI subpopulations.[12-14] Nevertheless, the lifetime direct costs that cover all ranges of neurologic impairment and age groups have not been examined since the late 1990s.

Top Spinal Cord Inj Rehabil 2011;16(4):10–16

www.thomasland.com

doi: 10.1310/sci1604-10

Table 1. Annual direct charges and costs by neurologic category (2009 US dollars)

	Neurologic category			
	C1-4 ABC	**C5-8 ABC**	**T1-S5 ABC**	**AIS D**
Annual direct charges				
First year ($t = 1$)	953,360	688,886	464,633	311,141
After first year ($t > 1$)	165,554	101,560	61,550	37,792
Annual direct costs[a]				
First year ($t = 1$)	423,152	293,529	191,431	122,753
After first year ($t > 1$)	150,508	89,254	49,147	33,535

[a]Adjusted by the cost to charge ratios or insurance reimbursement rates.

The present analysis was therefore conducted to update previous estimates of lifetime direct costs for vaious age and neurologic categories,[7] using recent data on life expectancy and direct costs of care after SCI in the United States. We believe that the new and improved estimation is not only important for persons with SCI and their families for life care planning, but also needed by rehabilitation counselors, psychologists, case managers, insurance companies, and lawyers seeking appropriate compensation for their injured clients. Given the current political climate of health care reform and for the purpose of public health awareness, it is critical to re-estimate lifetime costs to ensure that appropriate national resources are allocated for prevention activities, research initiatives, and health services and delivery for SCI.

Methods

For a comparison purpose, as in the previous study,[7] direct costs are referred to as those charges that are incurred by persons with SCI and their responsible third parties, which are the direct result of the injury. Charges pertaining to medical conditions that are not directly related to SCI are not considered. The lifetime direct costs are defined as total direct charges over the remaining life of an individual with SCI, which is determined by the direct charges every year and probabilities that an individual will still be alive each year to incur those charges. Because costs of care and mortality rate vary greatly by severity of injury, the lifetime direct costs were estimated seprately for the 4 neurologic groups: (1) C1-C4 with AIS A, B, or C; (2) C5-C8 with AIS A, B, or C; (3) T1-S5 with AIS A, B, or C; and (4) AIS D injuries at any level. Those persons who used ventilation support were included in the first group (C1-C4 with AIS A, B, or C) regardless of the level and completeness of injury. The lifetime costs are also presented by age at injury, because age is significantly associated with annual mortality after SCI.

Annual charges and costs

The costs of care following SCI are typically estimated for the first year of injury and then on an annual recurring basis after year 1 under the assumption that the costs are relatively constant over time after the first year of injury. In an article appearing elsewhere in this issue of *Topics in Spinal Cord Injury Rehabilitation*, based on data from the NSCISC database and other sources, DeVivo et al provide the latest estimation of direct charges and costs during the first year of injury and also recurring annual charges and costs after the first year (see **Table 1**).[15] The new estimation covers emergency medical services, inpatient hospital charges and costs, nursing home, outpatient therapies, outpatient physician fees, durable medical equipment, environmental modification, medications, suppplies, attendant care, vocational rehabilitation, and miscellaneous charges.

Probabilities of survival after SCI

The cumulative survival probability after SCI for each incremental age was estimated by using the standardized mortality ratio (SMR) method.[16]

Table 2. Calculation of standardized mortality ratio (SMR) by neurologic category

	Neurologic category			
	C1-4 ABC	C5-8 ABC	T1-S5 ABC	AIS D
Observed death	2,591	2,589	2,773	1,845
Expected death	271	517	858	1,071
SMR	9.55	5.01	3.23	1.72

The SMR is the ratio of the total number of deaths actually observed in the SCI population to the total number of deaths expected if persons with SCI had had the mortality experience of the general population. The total number of deaths observed for each neurologic group, as of December 31, 2009, was retreived from data on 42,775 persons with SCI who survived the first 24 hours of injury and registered in the NSCISC database. The total number of deaths expected was estimated separately for the 4 neurologic groups by applying the mortality rates for the general US population in 1997 to the study sample, adjusted for age, sex, and race. We chose year 1997 because it is roughly the mid-year of follow-up for the study population. The results of SMR calculation are summarized in **Table 2**. A constant SMR for each neurologic group was then applied to the latest age-specific mortality rate for the US general population (2006)[17] to create life tables for the SCI population, stratified by the neurologic categories. Based on this life table that takes the severity of SCI into account, the probability of dying and surviving each year can be estimated. The cumulative survival probability is then computed as the product of the probability of surviving at previous years and the probability of surviving at the present interval for each neurologic category.

Lifetime direct costs

The lifetime direct costs in this study are calculated as present value (PV) of future costs, which can be interpreted as funds set aside at present in escrow for use throughout the lifetime. Applying the same methodology as the previous study,[7] we computed the PV lifetime direct costs, separately for each of the 4 neurologic groups, by summing the product of annual direct charges and cumulative survival probability, adjusted for inflation and investment gain over time:

$$\text{PV life time direct costs} = \Sigma(DC_t)(PS_t)/(1+d)^{t-1}$$

In this formula, t is the number of years post injury. DC_t is the average direct costs in postinjury year t, which equals one of the two figures: charges that occurred during the first year of injury (t=1), and annual recurring charges after the first year ($t > 1$). PS_t is the cumulative survival probability in postinjury year t given survival to the year t-1, using the SMR method.[16]

As one dollar today can be worth more than one dollar in the future due to the interest earned between now and then, d represents the discount rate that reflects the real rate of return on investments over and beyond inflation. Four different discount rates were used in the present analysis: 0%, 2%, 4%, and 6%. The choice of a discount rate depends on anticipated real investment returns. For example, assuming the overall inflation rate over the remaining lifetime is 6% per year and investment return rate is 10% per year, then a 4% discount rate can be used as an adjustment. **Table 3** illustrates the results of an analysis for persons injured at age 25 with AIS D injury, who have survived the first 24 hours after injury, assuming 4% discount rate.

Results

The average lifetime direct costs, presented as charges, for those injured at ages 25 and 50 with various neurologic categories are summarized in

Table 3. Analysis of present value of average lifetime direct charges (2009 US dollars) for persons injured at age 25 with AIS D injury using 4% discount rate

Years post injury (t)	Current age	Annual mortalities for general population	Annual mortalities for AIS D group[a]	Cumulative survival probability for AIS D group (PS_t)	Annual costs[b]
1	25-26	0.001019	0.00175268	0.99824732	310595.67
2	26-27	0.001006	0.00173032	0.996520033	36212.00
3	27-28	0.000998	0.00171656	0.994809446	34759.47
4	28-29	0.001002	0.00172344	0.993094952	33364.96
5	29-30	0.001018	0.00175096	0.991356082	32025.52
6	30-31	0.001042	0.00179224	0.989579334	30738.58
7	31-32	0.001072	0.00184384	0.987754708	29501.83
8	32-33	0.001113	0.00191436	0.98586379	28312.84
9	33-34	0.001156	0.00198832	0.983903578	27169.75
10	34-35	0.001212	0.00208464	0.981852493	26070.30
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
75	99-100	0.30381	0.5225532	0.000523137	1.09

Note: Standardized mortality ratio (SMR) for AIS D group = 1.72. First-year charges (DC_t when t=1) = 311,141. Annual charges after year 1(DC_t when t >1) = 37,792. Sum of annual costs (ie, present value of average lifetime direct charges) = 1,072,243. Rows 11 through 74 have been omitted.

[a]It is the product of SMR (1.72) and annual mortalities for general population.

[b]$(DC_t)(PS_t)/(1+d)^{t-1}$

Table 4. Using a 4% discount rate, the lifetime direct charges for an individual injured at age 25 would range on average from 3.5 million dollars for the C1-C4 group to 1.1 million dollars for the the AIS D group. Because of a shorter life expectancy, the lifetime direct charges for a person injured at age 50 would reduce to 2.1 million dollars and 0.9 million dollars for the same groups. If health care price inflation equals future interest rates, the 0% discount rate would be a better choice, and the lifetime direct charges would consequently increase substantially, which ranges from 5.4 million dollars for the C1-C4 group to 2.1 million dollars for the AIS D group for persons injured at age 25.

As someone may argue that the charges are not the actual costs paid by persons or their third parties, the cost data provided by DeVivo

Table 4. Present value of average lifetime direct charges (2009 US dollars) for persons with SCI by age at injury, neurologic category, and assumed discount rates

Age at injury, years	Discount rate	Neurologic category			
		C1-4 ABC	C5-8 ABC	T1-S5 ABC	AIS D
25	0	5,431,821	4,166,101	2,878,134	2,061,926
	2	4,230,089	3,090,767	2,068,495	1,413,206
	4	3,465,950	2,455,450	1,612,937	1,072,243
	6	2,955,847	2,055,754	1,337,133	876,286
50	0	2,553,696	2,167,082	1,588,812	1,217,591
	2	2,324,785	1,901,098	1,357,491	997,480
	4	2,144,394	1,703,872	1,193,095	850,499
	6	1,999,896	1,554,162	1,072,821	748,514

Table 5. Present value of average lifetime direct costs (2009 US dollars) adjusted by the cost to charge ratios or insurance reimbursement rates

Age at injury, years	Discount rate	Neurologic category			
		C1-4 ABC	C5-8 ABC	T1-S5 ABC	AIS D
25	0	4,498,914	4,166,101	2,119,176	1,676,594
	2	3,406,399	2,405,967	1,472,688	1,100,947
	4	2,711,708	1,847,631	1,108,930	798,391
	6	2,247,964	1,496,366	888,704	624,508
50	0	1,896,705	1,599,495	1,091,631	928,259
	2	1,688,598	1,365,741	906,924	732,942
	4	1,524,601	1,192,412	775,655	602,518
	6	1,393,235	1,060,843	679,617	512,021

et al using the cost to charge ratios or insurance reimbursement rates were applied in the analysis to estimate the lifetime direct costs (**Table 5**). For a person injured at age 25, using a 4% discount rate, the lifetime direct costs would range on average from 2.7 million dollars for the C1-C4 group to 0.8 million dollars for the the AIS D group.

Discussion

Our previous estimates of direct lifetime costs[7] have been updated by the NSCISC, on a yearly basis, adjusting to current dollars based on the Medical Care Component of the Consumer Price Index and published in the Facts and Figures at a Glance on the NSCISC Web site (https://www.nscisc.uab.edu). These annual updates assume that similar hospital care, health care service, and technology are currently utilized as when the previous study was conducted in 1992 and also that the survival probability has not changed between now and then. As noted in **Figures 1** and **2**, the present study using the latest data on survival and annual charges shows substantially higher lifetime costs than previous estimates adjusted to 2009 dollars,[5] regardless of neurologic category. Assuming a 2% discount rate, the present estimate of lifetime direct costs for an individual injured at age 25 increase from 3.3 million to 4.2 million dollars for the C1-C4 group and from 0.7 million to 1.4 million dollars for the AIS D group.

The increase in lifetime direct costs since 1992 could be explained primarily by 2 factors: (1) improved life expectancy after SCI for those who survive at least 24 hours, and (2) increased costs of care following SCI. For example, the life expectancy for people injured at age 25 and surviving the first 24 hours of injury has increased from 22.4 years in 1992[18] to 31.2 years in 2009[19] for the C1-C4 group, increased from 30.5 to 35.3 years for the C5-C8 group, increased from 38.1 to 40.3 years for the T1-S5 group, and increased from 43.3 to 47.7 years for the AIS D group. The increased costs of care are demonstrated in an article appearing elsewhere in this issue of the journal, including acute care charges, rehospitalization charges, attendant care costs, and rehabilitation charges that are significantly higher than the inflation-adjusted estimates based on the previous study in 1992.[15] Other studies also demonstrate that the inpatient costs and long-term rehabilitation costs of SCI were rising faster than inflation.[10,11]

The present study findings need to be interpreted with caution because of several limitations. First, there are assumptions made for the analysis of the lifetime costs, which might result in under- or overestimation of the real costs. For example, we assume that the direct costs after the first postinjury year are constant over time. However, there is evidence that the direct costs increase substantially during the last few years of life in persons with SCI.[14,20] We also assume a constant SMR with advancing age, which tends to underestimate the longer term survival probabilities and life expectancy.[16]

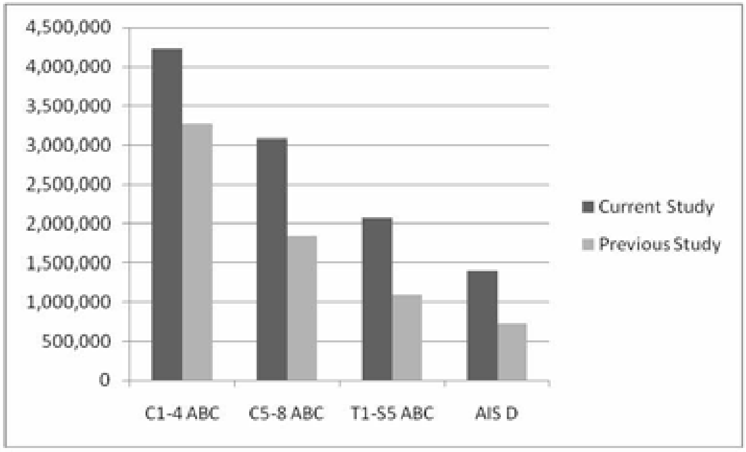

Figure 1. Comparison of lifetime direct charges (2009 dollars, with 2% discount rate) between previous study in 1992[5] and current study for persons injured at age 25.

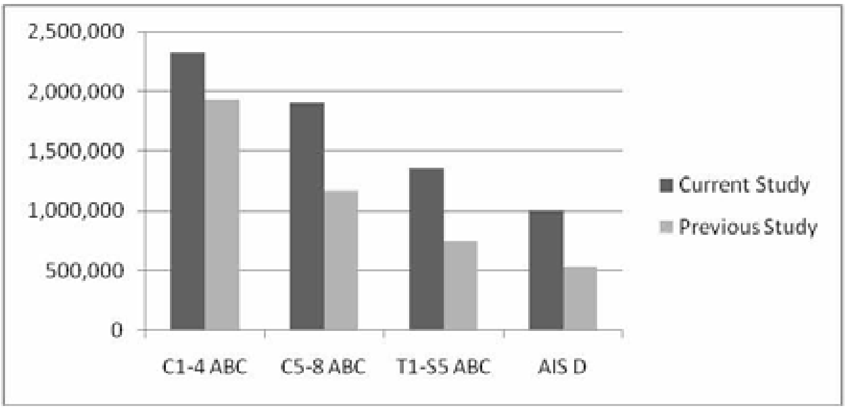

Figure 2. Comparison of lifetime direct charges (2009 dollars, with 2% discount rate) between previous study in 1992[5] and current study for persons injured at age 50.

Second, the present figures do not take unmet needs of people with SCI into consideration and do not account for the indirect costs such as losses in wages, fringe benefits, and productivity. Therefore, these estimates are conservative. Third, the NSCISC database is not population-based, but includes only persons who were treated at the SCI Model Systems. The survival probabilities and lifetime costs estimated by using the NSCISC sample might not be applicable to persons treated elsewhere.

Conclusion

Our study findings suggest that even with a shorter length of stay and the federal government's efforts to curtail the costs of health care, the lifetime direct costs today are much higher than what has been expected based on inflation-adjusted data from the 1990s. This increase is attributable to both the improvement in life expectancy in the SCI population and an increase in costs of care after SCI. These estimates are average lifetime charges and costs, which is better suited as a rough guide to the planning of life care and assessment of public health impact, for instance. As the categories used in this analysis are rather broad, considerable differences could exist within each category. As a result, these figures cannot replace any professionally developed life care plan that includes consideration of demographic and clinical characteristics of an individual and his/her actual needs.

Acknowledgment

This work was supported in part by grant H133A060039 from the National Institute on Disability and Rehabilitation Research (NIDRR), Office of Special Education and Rehabilitation Services, US Department of Education, Washington DC.

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Characteristics and Outcomes of Aged Medicare Beneficiaries with a Traumatic Spinal Cord Injury: 2002-2005

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The number of aged Medicare fee-for-service patients with a recent traumatic spinal cord injury (TSCI) treated in inpatient rehabilitation facilities (IRFs) increased from 608 in 2002 to 840 in 2005. Each year, more than half of patients presented with incomplete cervical level injuries. The mean case mix index increased from 1.87 to 2.03 during the 4 years, and the percentage of patients discharged to the community decreased from 62.7 in 2002 to 55.5 in 2005. The median price of an IRF hospital stay was $16,995 (2002 US dollars) in 2002 and $21,625 (2005 US dollars) in 2005. **Key words:** *Medicare, outcome assessment (health care), rehabilitation, spinal cord injury*

Epidemiologic studies examining the incidence of traumatic spinal cord injury (TSCI) have noted an increase in the number of elderly who acquire a new TSCI in Canada and Finland.[1, 2] In the United States, the mean age of patients admitted to the SCI Model System Centers has increased from 28.8 for the years 1973 to 1981 to 38.3 for the years 2002 to 2006.[3] This shift is attributed, in part, to the aging population, a trend that will continue.[4, 5] However, little is known about this subgroup of individuals with a TSCI. Jakob[6] and Furlan[7] found that elderly patients had difficulties translating neurological improvements into functional improvements, and several recent studies have found a higher prevalence of comorbidities among these patients.[8, 9]

The purpose of this descriptive study is to report trends in the sociodemographic and clinical characteristics and hospital stays of aged Medicare fee-for-service patients with a new TSCI discharged from inpatient rehabilitation facilities (IRFs) in the United States during the years 2002 through 2005. We expected to observe an increase in the number of elderly patients with a TSCI. Medicare claims and assessment data are well suited to examine the delivery of health care services for the elderly, because the files contain 100% of the billing records for covered health services provided to Medicare fee-for-service beneficiaries, who comprise approximately 84% of US residents aged 65 and older.

Methods

Data source and datasets

This is a descriptive study involving secondary analysis of Medicare claims and assessment data. We obtained the data from the Centers for Medicare & Medicaid Services after approval from the Centers for Medicare & Medicaid Services Privacy Board and Northwestern University's Institutional Review Board. Three types of data files were used in the analyses: (1) the Medicare Provider Analysis and Review (MedPAR) file (claims data); (2) the Inpatient Rehabilitation Facility – Patient Assessment Instrument (IRF-PAI) file (assessment data); and (3) the Denominator file.

Top Spinal Cord Inj Rehabil 2011;16(4):17–26

www.thomasland.com

doi: 10.1310/sci1604-17

MedPAR file

MedPAR data are patient-level Medicare billing (ie, claims) records; variables include demographic, medical diagnoses, procedures, service dates, length of stay (LOS), discharge status, charges, payment, and provider data. There is a unique MedPAR record for each hospital stay, so patients have 2 MedPAR records: 1 for the acute care hospital stay, and 1 for the inpatient rehabilitation hospital/unit stay.

IRF-PAI data

The patient assessment data set, the IRF-PAI,[10-12] includes demographic, hospital stay, diagnostic, discharge, and functional status data.[10] Demographic data include date of birth, gender, marital status, race, and ethnicity. Diagnostic data include the primary rehabilitation impairment and *International Classification of Disease, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes for the etiologic diagnosis and comorbidities. Functional status data include admission and discharge FIM* ratings for 13 motor and 5 cognitive skills. The FIM instrument documents the severity of disability and the outcomes of rehabilitation care.[10] Clinicians rate each of the 18 FIM items on a 7-level rating scale at admission and discharge, with higher ratings indicating greater independence. Previous studies have found the FIM instrument to be reliable, valid, and responsive for IRF patients.[13-19]

Denominator file

The Denominator file contains a scrambled identifier and demographic data and confirms the Medicare status of beneficiaries.

Linking data sets

We created a database of patient records by linking 4 types of patient-level records into a single (acute care + IRF) episode record for each patient. For each episode, the 4 linked data files were: (1) the MedPAR file for the *rehabilitation stay*, (2) the MedPAR file for the *acute care stay* immediately prior to the rehabilitation stay, (3) the IRF-PAI file for the *rehabilitation stay*, and (4) the Denominator file.

We matched 89.6% of all IRF MedPAR records with IRF-PAI records in 2002, 91.5% in 2003, 91.5% in 2004, and 91.1% in 2005.

Identifying the records of patients with a recent onset TSCI within the linked database of all IRF patients was challenging, because the IRF-PAI instructions direct clinicians to code the impairment group code as TSCI for patients with a chronic TSCI admitted for a new medical issue (eg, pressure ulcer). The date reported as the onset date may be the onset of the TSCI or the onset of a complication leading to a rehospitalization, so a new injury cannot be identified based on the onset date. In addition, the etiologic diagnoses listed for the impairment group code of TSCI is broader than the *ICD-9-CM* codes used by the Centers for Disease Control and Prevention (CDC) to define TSCI.[20] We used several variables to identify our sample of patients with a recent TSCI. We began by selecting the records of patients that included the *ICD-9-CM* between 806.00 and 806.9 (fracture of vertebral column with spinal cord injury) or between 952.00 and 952.9 (spinal cord injury without evidence of spinal bone injury), which are the *ICD-9-CM* codes used by the CDC to identify patients with a TSCI.[20] The number of patient records was restricted further by requiring that the impairment group code on the IRF-PAI record be between 4.210 and 4.230 (traumatic spinal cord injury) or 14.1 or 14.3 (multiple trauma with spinal cord injury). A labeling error in the 2002 IRF-PAI manual may have led to some incorrect impairment group coding, so we also included patient records in which the *ICD-9-CM* codes for the etiologic diagnosis was in the 806 or 952 series and the impairment group code was between 4.110 and 4.130 (nontraumatic spinal cord injury). To limit our sample to new injuries, we excluded the records of patients with an onset time to rehabilitation admission longer than 90 days, patients not admitted as an "initial rehabilitation" patient, and patients not admitted to rehab directly from an acute care unit. We excluded patients younger than 65, because we wanted to focus on

*FIM™ is a trademark of Uniform Data System for Medical Rehabilitation, a division of UB Foundation Activities, Inc.

elderly patients and because patients younger than 65 are eligible for Medicare due to having a disability and may have a chronic TSCI. After applying these inclusion and exclusion criteria, our sample was 2,919 patients discharged from 809 IRFs between 2002 and 2005.

Each patient was included in the analysis only once. Some patients had more than 1 IRF stay due to a return to acute care. If the time between the 2 IRF stays was 30 days or less, the IRF records were merged and were considered 1 stay. If the 2 IRF stays were separated by an interruption of more than 30 days, only the first IRF stay was included in the analysis.

Variables

Definitions for key variables are provided as follows.

Race/ethnicity: Race/ethnicity data are reported in the MedPAR data file, the Denominator data file, and the IRF-PAI data file. We used the IRF-PAI's race/ethnicity data for this analysis, because the IRF-PAI data are most consistent with current standards and permit more than 1 group to be selected.

Medicaid/Medicare: Patients were considered dually covered if Medicaid was checked as either the primary or secondary payer on the IRF-PAI record.

Diagnosis: The diagnosis for patients is based on the admission impairment group code reported on the IRF-PAI record or the *ICD-9-CM* codes reported in the MedPAR IRF record, the MedPAR acute care record, or the IRF-PAI record. For patients who had a specified injury level and an unspecified completeness and who were walking at rehabilitation discharge, the injury was recorded as incomplete.

Case mix index: The case mix index was assigned to patients using the case mix group/comorbidity tier weights used for the IRF prospective payment system (PPS). Case-Mix Group version 1.0[10] (used for the IRF-PPS in FYs 2002-2005) was used for all patient records for consistency, even though the IRF-PPS revised the case mix group assignments and case mix weights in fiscal year 2006 (starting October 1, 2005). In the PPS, the case mix index represents the costliness of a patient relative to the costliness of the average Medicare fee-for-service patient, and it is a proxy for the case mix complexity of the patients. A case mix group/comorbidity weight value of 1 represents the average cost of all Medicare fee-for-service, and a weight value of 2 indicates that the patient is twice as costly as the average patient.

Onset time refers to the number of days between the onset date (from the IRF-PAI file) and the rehabilitation admission date (from the IRF MedPAR file). Patients with onset times greater than 90 days are excluded from analyses.

Length of stay (LOS) is the number of days spent on the rehabilitation service and reported in the IRF MedPAR file. It is calculated by subtracting the date of discharge from the date of admission. If the difference is 0, the value is recoded to 1. If a patient had 2 IRF stays with an interruption time of 30 days or less, the number of days during the 2 IRF stays were summed.

Home and community-based discharge location is a discharge to a community-based setting, including a home, board, and care setting, transitional living setting, or an assisted living setting. We used the discharge destination reported in the IRF-PAI records.

Medicare price: The total amount paid to the rehabilitation hospital/unit for Part A services from all sources, including Medicare (Part A), the beneficiary, and other payers. It is the sum of 6 variables from the IRF MedPAR file: (1) the Medicare payment, (2) the total pass through amount, (3) the beneficiary primary payment, (4) the beneficiary Part A co-insurance, (5) the beneficiary inpatient deductible, and (6) the beneficiary blood deductible.

FIM ratings: Admission, discharge, and change FIM scores were calculated for patients with an

IRF-PAI record who were discharged alive. The FIM self-care items are eating, grooming, bathing, dressing upper body, dressing lower body, and toileting. The FIM mobility items are transfer – bed, chair, wheelchair; transfer toilet; transfer – tub or shower; walk or wheelchair; and stairs. The function modifier data were used to report bladder and bowel management.

Data linking and descriptive analyses were conducted using SAS 9.2 (SAS Institute, Inc, Cary, North Carolina) and SPSS 17.0 (SPSS, Inc, Chicago, Illinois). We tested for differences across the 4 years using one-way analysis of variance (ANOVA) and chi-square tests.

Results

The number of Medicare fee-for-service cases was 608 in 2002 and 840 in 2005, an increase of 38.1% (**Table 1**). The percentage of patients who were men was similar across the years and was 54.0 in 2005. The age distribution of patients showed that fewer than 18% were 85 years or older. The percentage of beneficiaries who were white decreased slightly between 2002 and 2005, from 87.5 to 83.8, which follows the trend of the entire Medicare population. Approximately half of the patients were married and between 7.9% (2002) and 9.8% (2005) were dually covered by Medicare and Medicaid.

Table 2 reports the distribution of the patients' primary diagnosis. About 30% of the patients had an incomplete C01 to C04 injury, and approximately 28% had an incomplete C05 to C08 injury. The next most frequent diagnoses were lumbar injury (approximately 12%) followed by incomplete injuries within the T07 to T12 levels (approximately 9%). For several diagnoses groups, we report an "*" indicating that fewer than 11 patients were included in this group, which is required as part of our Data Use Agreement.

Table 3 characterizes the hospitalization experience of aged Medicare fee-for-service beneficiaries treated in IRFs. The percentage of patients with a reported traumatic brain injury (TBI) showed a slight increase across the 4 years, from 5.9% to 9.3%, but the difference was not statistically significant. The percent of patients with tier 1, tier 2, and tier 3 comorbidities also tended to increased during the study period, but this difference was not statistically significant. The mean (*SD*) case mix index increased from 1.87 (0.75) to 2.03 (0.78), but the median onset times and length of stays were not significantly different during the 4 years. The percentage of patients discharged to the community (home or a community-based setting) decreased by 7.2 percentage points between 2002 and 2005, a significant difference. The percentage of patients discharged to an acute care hospital increased slightly in 2005, but this difference was not statistically significant. Postdischarge 90-day mortality ranged from 9.2% (2004) to 9.8% (2003). The median price of an IRF hospital stay was $16,995 (2002 US dollars) in 2002 and $21,625 (2005 US dollars) in 2005.

Table 4 reports hospitalization data for the 2 most frequent diagnosis groups. For patients with a C01 to C04 incomplete injury, between 2002 and 2005, the mean (*SD*) case mix index increased significantly from 1.89 (0.79) to 2.13 (0.85), and the mean (*SD*) LOS increased from 20.6 (15.1) to 24.5 (17.9) days. The community discharge percent decreased slightly from 63.2% to 57.2%, but this difference was not statistically significant. Among patients with a C05 to C08 incomplete injury, case mix index increased across the years.

Table 5 reports the admission, discharge, and change in FIM ratings (where higher values denote greater independence) by subscale for patients with incomplete cervical injuries who were discharged alive. Among patients with a C01 to C04 incomplete injury, the mean (*SD*) admission FIM rating for the self-care items decreased 2.0 FIM units between 2002 to 2005, from 15.2 (8.1) to 13.2 (7.1) and mean (*SD*) discharge scores decreased from 24.8 (10.8) to 22.8 (10.7), but the change in self-care score was not significantly different. Similarly, the mean (*SD*) mobility FIM scores decreased on admission, from 9.7 (4.8) to 8.8 (4.1), and discharge, from 18.8 (8.6) to 17.3 (8.0), but the change in FIM mobility scores were not significantly different. The function modifier items provide data on bladder and bowel management. The percent of patients independent (completely

Table 1. Sociodemographic characteristics of aged Medicare fee-for-service patients with a recent onset traumatic spinal cord injury discharged from inpatient rehabilitation facilities, 2002 to 2005

Characteristic	2002	2003	2004	2005
Number of patients	608	660	811	840
Gender, %				
Males	53.9	54.8	55.4	54.0
Females	46.1	45.2	44.6	46.0
Age, %				
65 to 74 years old	41.0	42.9	38.7	43.9
75 to 84 years old	44.2	41.1	44.0	39.9
85 years and older	14.8	16.1	17.3	16.2
Race/ethnicity, %				
White	87.5	83.5	85.3	83.8
Black or African American	7.6	11.1	8.0	10.2
Asian	1.6	1.7	2.3	1.8
Hispanic or Latino	2.1	2.6	3.0	3.5
North American Native	0.8	0.5	0.6	0.4
Hawaiian or Pacific Islander	0.2	0.3	0.6	0.2
Multi-race/ethnic	0.2	0.5	0.1	0.1
Currently married, %	52.1	51.9	53.7	55.4
Dually covered: Medicare/Medicaid, %	7.9	8.0	8.1	9.8
Preinjury living alone	32.3	32.1	30.9	30.1

Table 2. Diagnoses of aged Medicare fee-for-service patients with a recent onset traumatic spinal cord injury discharged from inpatient rehabilitation facilities, 2002 to 2005

Spinal cord injury diagnosis	2002	2003	2004	2005
C01 to C04, n (%)				
Complete injury	*	*	*	11 (1.3)
Incomplete injury	193 (31.7)	202 (30.6)	250 (30.8)	243 (28.9)
Unspecified injury	17 (2.8)	18 (2.7)	19 (2.3)	22 (2.6)
C05 to C08, n (%)				
Complete injury	13 (2.1)	13 (2.0)	11 (1.4)	*
Incomplete injury	180 (29.6)	180 (27.3)	221 (27.3)	233 (27.7)
Unspecified	*	14 (2.1)	20 (2.5)	20 (2.4)
T01 to T06, n (%)				
Complete injury	*	*	*	*
Incomplete injury	27 (4.4)	34 (5.2)	32 (3.9)	42 (5.0)
Unspecified injury	*	*	*	14 (1.7)
T07 to T012, n (%)				
Complete injury	12 (2.0)	*	16 (2.0)	15 (1.8)
Incomplete injury	50 (8.2)	53 (8.0)	80 (9.9)	87 (10.4)
Unspecified injury	11 (1.8)	17 (2.6)	23 (2.8)	22 (2.6)
Cauda equina injury, n (%)	*	*	*	*
Lumbar injury, n (%)	69 (11.3)	92 (13.9)	109 (13.4)	101 (12.0)
Sacral injury, n (%)	*	*	*	*

* Indicates that fewer than 11 patients had this diagnosis.

Table 3. Hospitalization characteristics and discharge destination of aged Medicare fee-for-service patients with a recent onset traumatic spinal cord injury discharged from inpatient rehabilitation facilities, 2002 to 2005

Characteristic	2002	2003	2004	2005
Multiple trauma, %				
Traumatic brain injury	5.9	8.9	8.6	9.3
Multiple fractures/amputation	2.8	2.4	2.1	2.0
Tiered comorbidities, %				
Tier 1(most costly)	4.9	5.8	5.5	7.7
Tier 2	12.5	12.9	18.9	16.4
Tier 3 (least costly)	13.8	14.4	14.7	18.5
Case mix index, mean (*SD*)**	1.87 (0.75)	1.87 (0.76)	1.98 (0.77)	2.03 (0.78)
Onset time, days, median (IQR)	8 (6-14)	9 (5-15)	8 (5-16)	9 (5-15)
Onset time, days, mean (*SD*)	12.1 (11.3)	13.1 (13.1)	12.9 (13.2)	13.1 (13.0)
Length of stay, days, median (IQR)	18 (10-29)	18 (11-29)	18 (12-28)	18 (11-29)
Length of stay, days, mean (*SD*)	21.2 (14.6)	21.3 (14.9)	20.7 (13.1)	22.1 (15.4)
Discharge setting, %				
Home and community-based location**	62.7	61.8	60.5	55.5
Nursing home	*	*	*	*
Acute care	12.7	11.5	11.8	15.4
Died during inpatient rehabilitation stay	*	*	*	*
Post-IRF discharge mortality, %				
Died 1 to 30 days post discharge	4.3	3.8	4.6	5.6
Died 1 to 60 days post discharge	7.8	6.8	6.9	7.9
Died 1 to 90 days post discharge	9.3	9.8	9.2	9.4
Price in US dollars, mean (*SD*)**	19,928 (14,462)	22,427 (16,847)	22,795 (13,510)	24,183 (15,999)
Price in US dollars, median (IQR)	16,995 (10,798-26,699)	20,055 (12,440-28,180)	20,961 (12,941-30,369)	21,625 (13,387-31,388)
Medicare payment in US dollars, mean** (SD)	18,476 (13,397)	21,356 (15,545)	21,997 (13,056)	23,406 (15,267)
Medicare payment in US dollars, median (IQR)	16,187 (9,803-25,287)	19,327 (12,084-27,289)	20,377 (12,633-29,544)	21,783 (13,206-30,488)
Percent of patients with co-insurance or	21.5	20.4	20.6	19.0
deductible liabilities	812	840	876	912
Patient liability, mode				

Note: SD = standard deviation; LOS = length of stay; IQR = interquartile range.
* Indicates fewer than 11 patients.
**Differences are significantly different with $P < .05$.

or modified) with bladder and bowel management at admission was not significantly different across the years, but the percent independent (completely or modified) at discharge was lower in 2005 compared to 2002. The percent of patients who did not have accidents (FIM level 7 and 6) at admission and discharge was not significantly different across the years at admission or discharge.

For patients with a C05 to C08 incomplete injury, between 2002 and 2005, the mean admission and discharge FIM scores were lower for self-care and mobility subscales, but FIM change scores were not different. Independence (complete or modified) with bladder and bowel management was not different across the years at admission or discharge, and the percent of patients who did not have accidents (FIM level 7 and 6) at admission and discharge was not significantly different across the years at admission or discharge.

Discussion

The number of Medicare fee-for-service patients with a recent onset TSCI treated in IRFs increased 38.1% between 2002 and 2005. This increase is much higher than the 3% increase in the Medicare fee-for-service population during this same time frame and may reflect several other factors, such as a higher incidence of TSCI in the United States among individuals in this age group,[1-3] an increase

Table 4. Hospitalization characteristics and discharge destination of aged Medicare fee-for-service patients with a recent onset traumatic spinal cord injury discharged from inpatient rehabilitation facilities, 2002 to 2005

Characteristic	2002	2003	2004	2005
Patient with C01 to C04 incomplete TSCI				
Number of patients	193	202	250	243
Multiple trauma, %				
Traumatic brain injury	6.7	13.4	11.2	10.7
Tiered comorbidities, %				
Tier 1 (most costly)	6.2	7.4	5.6	12.8
Tier 2	12.4	15.3	20.8	16.9
Tier 3 (least costly)	15.0	16.3	12.4	13.2
Case mix index, mean (*SD*)**	1.89 (0.79)	1.90 (0.80)	2.10 (0.82)	2.13 (0.85)
Length of stay, days, median (IQR)	17 (9-28)	17 (10-28)	18 (12-28)	21 (11-31)
Length of stay, days, mean (*SD*)**	20.6 (15.1)	20.7 (14.0)	20.6 (12.0)	24.5 (17.9)
Discharge setting, %				
Home and community-based location	63.2	64.4	57.2	57.2
Nursing home	*	0.0	*	0.0
Acute care	13.5	9.9	10.0	11.9
Price in US dollars, mean (*SD*)**	19,332(13,170)	22,540 (15,551)	23,742 (13,270)	26,832 (18,225)
Price in US dollars, median (IQR)	15,960 (9,921–27,379)	20,215 (12,537–29,633)	22,050 (14,480-31,081)	22,649 (13,687-35,039)
Patient with C05 to C08 incomplete TSCI				
Number of patients	180	180	221	233
Multiple trauma, %				
Traumatic brain injury	7.2	7.2	10.9	11.2
Tiered comorbidities, %				
Tier 1 (most costly)	3.3	3.3	5.4	4.7
Tier 2	13.3	16.1	22.2	23.2
Tier 3 (least costly)	12.2	12.8	14.5	17.6
Case mix index, mean (*SD*)**	1.96 (0.83)	1.99 (0.80)	2.09 (0.80)	2.16 (0.80)
Length of stay, days, median (IQR)	18 (11-30)	21 (13-32)	21 (12-32)	20 (12-33)
Length of stay, days, mean (*SD*)	21.6 (13.9)	24.1 (16.4)	23.5 (15.2)	23.6 (15.8)
Discharge setting, %				
Home and community-based location	68.3	62.8	63.3	56.7
Nursing home	0.0	0.0	0.0	0.0
Acute care	11.7	11.1	11.3	14.2
Price in US dollars, mean (*SD*)**	20,088 (11,423)	23,965 (15,333)	24,884 (14,973)	25,975 (15,409)
Price in US dollars, median (IQR)	18,867 (11,099-28,045)	21,942 (12,679-31,699)	21,905 (12,808-33,025)	24,068 (14,660-34,947)

Note: SD = standard deviation; LOS = length of stay; IQR = interquartile range

*Indicates fewer than 11 patients.

**Differences are significantly different with $P < .05$.

in survival rates during the acute care phase,[8] and a higher level of access to IRF care.

The sociodemographic characteristics of these patients did not change, except that a slightly higher percentage of patients are minority race/ethnicity groups. This shift to more minority patients is consistent with changing characteristics of the Medicare population. The most notable change in the patients treated in IRFs was the increase in the case mix index value across the years, even within the 2 largest diagnosis groups (C01 to C04 incomplete injury and C05 to C08

Table 5. Self-care and mobility FIM ratings and bowel and bladder management ratings for Medicare fee-for-service patients with a recent onset traumatic spinal cord injury, 2002 to 2005

	All patients			
	2002	**2003**	**2004**	**2005**
Patients with C01 to C04 incomplete TSCI				
No. of patients	193	200	248	242
Self-care, mean (*SD*)				
Admission (maximum is 42 points)**	15.2 (8.1)	15.7 (7.6)	13.2 (7.5)	13.2 (7.1)
Discharge (maximum is 42 points)**	24.8 (10.8)	25.4 (9.3)	22.7 (11.2)	22.8 (10.7)
Change in self-care	9.6 (7.2)	9.7 (6.6)	9.5 (7.6)	9.6 (7.8)
Mobility, mean (SD)				
Admission (maximum is 35 points)**	9.7 (4.8)	10.1 (4.5)	9.1 (4.5)	8.8 (4.1)
Discharge (maximum is 35 points)**	18.8 (8.6)	19.5 (7.6)	17.6 (8.5)	17.3 (8.0)
Change in mobility	9.1 (6.5)	9.3 (5.9)	8.5 (6.5)	8.5 (6.2)
Bladder management: complete or modified independence (FIM modifier level 6 or 7), %				
Admission	14.0	11.5	12.1	7.9
Discharge**	44.0	44.5	31.9	27.3
Bowel management: complete or modified independence (FIM modifier level 6 or 7), %				
Admission	30.6	26.5	22.6	24.8
Discharge**	53.4	57.0	44.0	46.3
Bladder continence: no accidents (FIM modifier level 6 or 7), %				
Admission	74.1	72.5	75.8	73.1
Discharge	78.3	80.5	81.5	74.8
Bowel continence: no accidents (FIM modifier level 6 or 7), %				
Admission	68.9	67.0	64.1	60.3
Discharge	79.3	80.5	74.2	71.9
Patients with C05 to C08 incomplete TSCI				
No. of patients	180	180	221	232
Self-care				
Admission (maximum is 42 points)**	14.0 (7.8)	14.3 (7.5)	13.3 (7.4)	12.2 (6.5)
Discharge (maximum is 42 points)**	23.9 (10.6)	24.6 (10.6)	23.3 (10.7)	21.7 (10.7)
Change in function	9.9 (8.1)	10.4 (7.7)	10.1 (7.8)	9.5 (7.9)
Mobility				
Admission (maximum is 35 points)**	9.4 (4.7)	9.1 (4.4)	8.8 (4.2)	8.3 (4.0)
Discharge (maximum is 35 points)**	18.8 (8.7)	18.7 (8.2)	17.8 (8.2)	16.2 (8.5)
Change in function	9.4 (6.7)	9.6 (6.4)	9.0 (6.1)	8.0 (6.6)
Bladder management: complete or modified independence (FIM modifier level 6 or 7), %				
Admission	15.0	8.3	11.3	7.3
Discharge	40.6	33.9	29.8	29.7
Bowel management: complete or modified independence (FIM modifier level 6 or 7), %				
Admission	22.8	20.6	24.0	25.0
Discharge	48.3	47.2	44.3	42.7
Bladder continence: no accidents (FIM modifier level 6 or 7,) %				
Admission	80.6	77.8	74.2	80.6
Discharge	85.0	79.4	82.8	79.3
Bowel continence: no accidents (FIM modifier level 6 or 7), %				
Admission	61.7	66.7	65.2	66.4
Discharge	73.9	75.6	76.0	75.4

Note: The rules for scoring discharge functional status changed on April 1, 2004. Self-care includes eating, grooming, bathing, dressing upper body, dressing lower body, toileting. Sphincter management includes bladder and bowel management. Mobility includes transfer – bed, chair, wheelchair; transfer toilet; transfer – tub or shower; walk or wheelchair; stairs. *SD* = standard deviation.

**Differences are significantly different with $P < .05$.

incomplete injury). For patients in both diagnosis groups, admission self-care and mobility scores were lower in 2005 compared to 2002.

There was a slight nonsignificant increase in the percent of patients with a diagnosed TBI in 2005 and a slight nonsignificant increase in the prevalence of comorbidities between 2002 and 2005. Although coding of comorbidities (as tiered comorbidities) and the multiple trauma (TSCI and TBI) impairment group have been part of the payment system since 2002, a small percentage increase over time may be tied to greater recognition that TSCI and TBI frequently co-exist as well as to better documentation.[21,22] LOS did not increase for all TSCI patients overall, but we did observe an increase in LOS for patients with a C01 to C04 incomplete injury.

Although the Medicare claims and assessment data offer an opportunity to report on the aged Medicare fee-for-service population, there is no systematic way of identifying those patients with a recent TSCI in these databases. IRF-PAI instructions[10] make it challenging to identify patients with a recent TSCI versus chronic TSCI admitted for a new medical issue (eg, pressure ulcer) based on the impairment group code, and the date reported as the onset date may be the onset of the TSCI or the onset of a condition (eg, pressure ulcer) leading to a rehospitalization. In addition, the list of etiologic diagnoses for the impairment group code of TSCI in the IRF-PAI Training Manual[10] is broader than the *ICD-9-CM* codes used by the CDC to define TSCI. We chose a conservative approach to selecting our sample by using the CDC definition and using several variables to restrict the sample to recent onset injuries. These variables included the etiologic diagnosis, the impairment group code, the onset date, admit from setting, and the admission class (eg, initial rehabilitation). Although we were not able to identify patients with a recent TSCI in one systematic way in this database, a limitation of this study, we tested several different approaches to identifying our sample; for each approach, we found an increase in the number of TSCI patients.

The increase in the number of elderly with a recent TSCI treated in IRFs has implications for the need for prevention measures. A major cause of TSCI among the elderly is falls, and Jabbour,[5] Kannus,[23] and Hagen[4] noted that the elderly are at risk for a TSCI due to several factors, including osteoporosis, osteopenia, and changes in bone quality that occur with aging as well as an increase in risk of falls due to sensory changes and medication effects. In addition, the elderly have a higher rate of motor vehicle incidents per mile driven.

Conclusion

The number of Medicare fee-for-service patients with a TSCI treated in US IRFs increased 38.1% between 2002 and 2005. Among these patients, there is a trend of increasing case mix complexity with lower discharge FIM self-care and mobility scores and fewer community discharges.

Acknowledgments

This work was funded by the US Department of Education, National Institute on Disability and Rehabilitation Research - Midwest Regional Spinal Cord Injury Care System; David Chen, MD, principal investigator: award number: H133N060014.

We thank Yu-ying Chen, MD, and Stephen T. Mennemeyer, PhD, for their feedback on an earlier version of the article.

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A Comparison of Costs and Health Care Utilization for Veterans with Traumatic and Nontraumatic Spinal Cord Injury

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The US Department of Veterans Affairs (VA) is the largest system of care for individuals with spinal cord injury/disorder (SCI/D) in the world. This article compares demographics, utilization, diagnoses, and associated costs between veterans with traumatic and nontraumatic SCI/D. Regression analyses were used to predict the effect of injury etiology on patient utilization and cost after controlling for covariates. Veterans with a nontraumatic SCI/D were significantly older with a greater number of comorbidities and outpatient utilization; however, there was no difference in health care costs between groups, and injury etiology was not a significant predictor of cost. Recommendations for future research based on these findings are offered. **Key words:** *health care costs, spinal cord injury, veterans.*

Approximately one quarter of a million individuals live with a serious spinal cord injury/disorder (SCI/D) in the United States. Of this number, over 42,000, or approximately 17%, are veterans of the US Armed Forces.[1] It is estimated that Veterans Healthcare Administration (VHA) offered comprehensive care to roughly 26,000 veterans with SCI/D in 2008. The VHA provides comprehensive, life-long services to veterans with traumatic and nontraumatic injuries, including primary and specialty care, rehabilitation, and long-term care. The most frequent causes of traumatic injuries include automobile accidents, motorcycle accidents, falls, sports injuries, and gunshot wounds. Common nontraumatic etiologies include spondylosis and spinal stenosis, infection, tumor, syringomyelia, and vascular disorders. The proportion of nontraumatic to traumatic injuries may be increasing as a result of the increased aging population.

Previous studies have reported utilization and associated costs for traumatic SCI[2-5]; however, utilization and cost involving nontraumatic SCI is poorly documented. Treatment of SCI/D in the first year of injury has been shown to differ by injury onset (traumatic vs nontraumatic) as reflected by differences in utilization patterns, such as higher number of internist and neurosurgeon visits for individuals with nontraumatic injuries compared to traumatic causes. Persons with traumatic injury have higher numbers of visits to urologists and physiatrists compared to individuals with nontraumatic injuries.[6]

Although a few studies have compared traumatic and nontraumatic SCI/D and health care utilization,[6,7] associated costs were not

Top Spinal Cord Inj Rehabil 2011;16(4):27–42

www.thomasland.com

doi: 10.1310/sci1604-27

examined. Understanding health care utilization and associated costs of veterans with SCI/D will provide information that is vital to the VA's mission of providing high-quality and efficient health care to veterans. This information is crucial for clinicians, planners, and policymakers. The objectives of this study were to compare demographic characteristics, utilization patterns, and health care costs, including hospital length of stay and pharmacy use, in a single year for veterans with traumatic and nontraumatic etiologies.

Methods

Study design

This study was a retrospective cohort design utilizing VHA administrative data. To be included, individuals had to be a veteran with SCI/D, alive at the beginning of fiscal year (FY) 2008 (October 1, 2007, through September 30, 2008) and have utilization within that FY (utilization defined as one or more visits/admissions to a VA facility). Veterans with both acute and chronic SCI/D were considered for inclusion. Primary outcomes included inpatient (IP), outpatient (OP), and pharmacy utilization and costs during FY 2008. This study was approved by the Hines VA Institutional Review Board and Research and Development Committees.

Study cohort

Selection of the study cohort was a multistep process utilizing a number of VA administrative databases. Beginning with the 2007 VA Allocation Resource Center (ARC) cohort (N = 46,206; see **Figure 1**), veterans deceased prior to the beginning of FY 2008 were excluded (n = 22,948). Veterans identified as having multiple sclerosis (MS) were then excluded as there is no way to directly determine if the spinal cord is affected using administrative data.[8] MS was defined using *International Classification of Diseases, Ninth Revision* (*ICD-9*) code 340 or the classification "MS" within the National Spinal Cord Dysfunction (SCD) Registry *Etiology* variable. Veterans with motor neuron disorders (eg, amyotrophic lateral sclerosis) were also excluded using *ICD-9* codes or the classification within the SCD Registry. Of the 26,387 veterans who met the inclusion criteria, 13,993 had utilization in FY 2008. Individuals only having fee basis care (care provided outside the VA but paid for by the VA) in FY 2008 were excluded (n = 71).

To classify SCI/D etiology, a combination of VA administrative variables and *ICD-9* codes were utilized. First, the SCD Registry *Etiology* variable was recoded into either traumatic (including, vehicular, fall, act of violence, sports injury, or other-traumatic) or nontraumatic (including, arthritic disease of the spine, poliomyelitis, tumor, infection or abscess, and other-disease). Next, *ICD-9* codes were examined to identify injury etiology for veterans missing SCD Registry *Etiology*.[3,9] Traumatic injuries were identified using *ICD-9* codes 806.X and 952.X.[10] Nontraumatic *ICD-9* codes were identified and classified in the following groups: myelitis (341.2), infection (045, 138, 094.0, 324.1), spondylosis/spinal stenosis (720, 721, 722.7, 723.0, 724.0), tumor (192.2, 192.3, 225.3, 225.4), ischemia/vascular (336.1, 747.82), degeneration (334.0, 334.1, 334.8, 334.9), spina bifida (741), syringomyelia (336.0, 742.53), other specified anomalies of the spinal cord (742.59), and subacute combined degeneration of the spinal cord (336.2). *ICD-9* codes were also used to classify veterans identified as having nontraumatic injuries from the SCD Registry *Etiology* variable.

Finally, for those missing the SCD Registry *Etiology* variable and not matching any of the *ICD-9* codes, the SCD Registry *Onset* and *SCIstat* variables were examined. The SCD Registry *Onset* variable consists of Traumatic, Nontraumatic, or Missing labels and *SCIstat* is comprised of Paraplegia–Traumatic, Paraplegia–Nontraumatic, Tetraplegia–Traumatic, Tetraplegia–Nontraumatic, Missing, and Not Applicable categories. The latter variable was recoded into the categories Traumatic, Nontraumatic, or Missing and merged with the *Onset* variable. Veterans missing an injury etiology classification (n = 1,242) and veterans with conflicting SCD Registry or *ICD-9* codes (ie, both traumatic and nontraumatic codes; n = 882) were excluded from analyses. Finally, veterans missing one or more demographic characteristic (age, race, gender, marital status, rurality, travel time to the

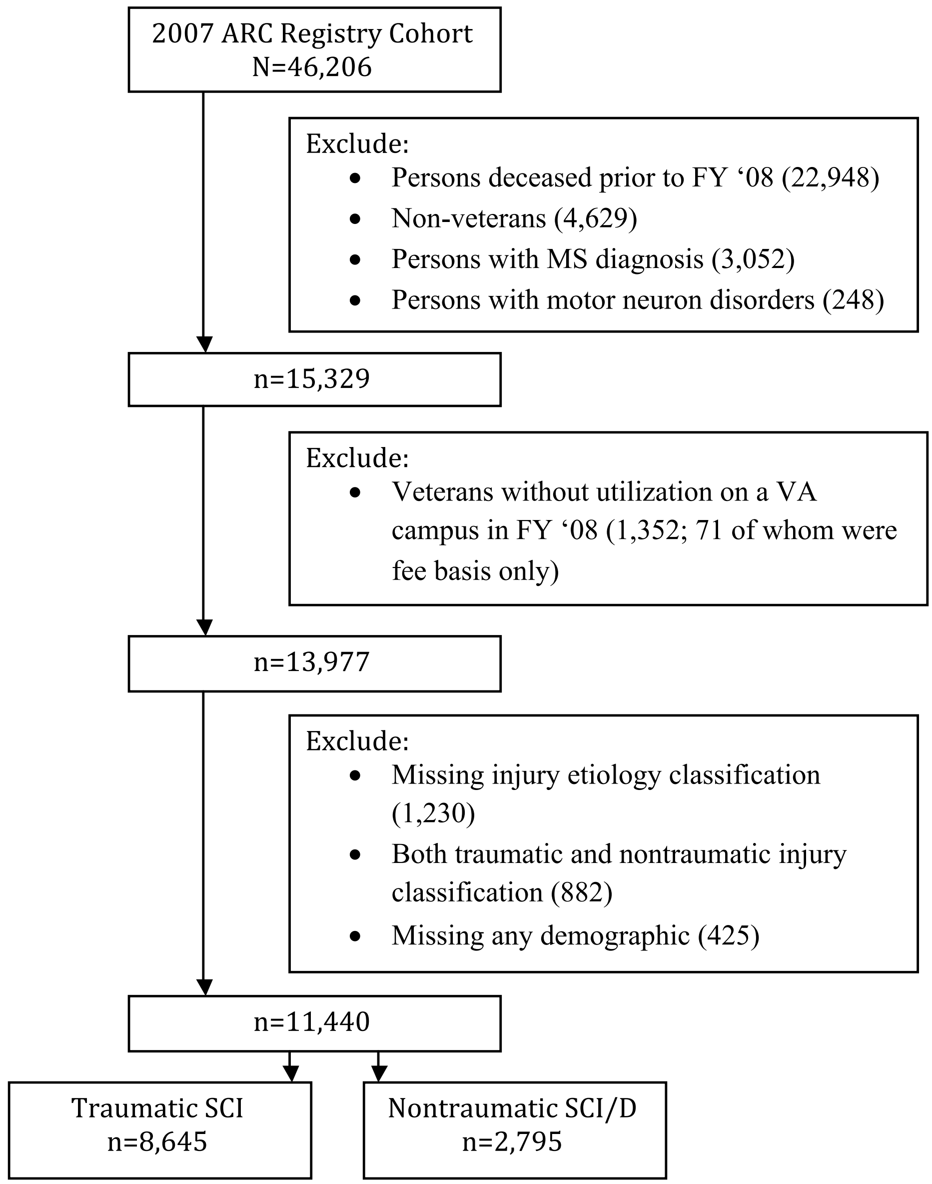

Figure 1. Patient identification and inclusion/exclusion. ARC = Allocation Resource Center; FY = fiscal year; MS = multiple sclerosis; VA = Veterans Affairs; SCI = spinal cord injury; SCI/D = spinal cord injury/disorder.

nearest VA, median income) were excluded (n = 425). The proportion of individuals excluded for missing demographics did not differ by injury etiology (3.9% nontraumatic vs 3.5% traumatic; $P = .260$); however, individuals missing demographic data had statistically significantly fewer total OP visits than those with demographic data (13.31 vs 15.59, respectively; $P = .016$).

Data sources

Data for this study came from national VA sources. We used the cohort of veterans with SCI/D created by the VA ARC, which maintains an ongoing registry of veterans with SCI/D that is used to allocate resources to VA medical centers. The list is updated yearly, is cumulative, and contains both traumatic and nontraumatic SCI/D; veterans are not removed once they are deceased. For this study, we used the FY 2007 ARC cohort. Additional SCI information was obtained from the SCD Registry, which includes information regarding etiology, date of onset, level of injury, completeness of injury, and other administrative and clinical data. Health care utilization was obtained from the VA Medical SAS Inpatient and Outpatient Datasets, which capture IP and OP utilization from the electronic record system of local VA medical centers,[11,12] and from Fee Basis files, which capture claims for non-VA services paid for by the VA. Pharmacy data were obtained from the Decision Support System (DSS) Pharmacy National Data Extracts (NDE), which capture medications dispensed through the electronic record system of VA medical centers.[13] OP pharmacy was categorized as chronic medications, defined as those for which a patient received more than one 30-day supply, and acute medications, defined as those medications for which a patient received no more than one 30-day supply. IP utilization included the total number of hospital days for short-term medical/surgical, SCI center, psychiatric, rehabilitation, and long-term care, based on time spent in that care unit (ie, VA bed section). Days of non-VA care financed by VA came from the VA Fee Basis databases. Because income data are often missing for veterans, we estimated median income by zip code from 2000 census data.[14] Travel time in minutes was calculated using patient zip code of residence to nearest VA facility using geographic information system software (Network Analyst) from the Environmental Science Research Institute in Redlands, California (ArcGIS 9.3). Urban, rural, and highly rural designations by zip code were obtained from the Planning System Support Group, a field unit from the Office of the Assistant Deputy Under Secretary for Policy and Planning. The VA definitions for urban, rural, and highly rural are partially based on census tract and partly on county. Census tracts that belong to an urbanized area are designated as urban; all other locations are considered rural except those counties with fewer than 7 civilians per square miles, which are designated as highly rural.[15]

Cost estimate

Our cost estimates reflect direct VA expenditures for patient care either provided at VA facilities or provided in non-VA facilities but paid for by VA. Costs for outpatient care, outpatient pharmacy, and hospitalizations were obtained from VA DSS NDEs. The DSS NDEs contain cost estimates of VA care derived from an activity-based cost allocation system that combines workload information from patient care and administrative departments to produce cost estimates for each patient's health care encounters (ie, outpatient visits or inpatient admissions).[16] These databases contain estimates of costs including pharmacy, personnel (physicians, nurses, technicians, etc), supplies, and other administrative/overhead expenses for IP/OP encounters. Pharmacy costs include direct costs of the medications as well as dispensing costs. Costs of non-VA hospitalizations financed by VA were obtained from the VA Fee Basis databases.[17] The cost estimates in this study do not include durable equipment, attendant care, and environmental modifications.

Analyses

To examine the unadjusted differences between demographic characteristics and health care utilization of veterans with traumatic and nontraumatic SCI/D, continuous demographic variables and utilization were analyzed using one-way analysis of variance (ANOVA) while categorical variables were analyzed using chi-square tests. Differences in OP pharmacy, IP care, nonacute hospitalizations, and costs were analyzed using bootstrapping approaches. Cost data are often skewed due to the presence of a minority of patients with extensive health care utilization and subsequently high costs. A bootstrapping approach allows for the calculation of the 95% confidence interval (95% CI) without making assumptions about the distribution of the data.[18] We calculated bias-corrected accelerated nonparametric bootstrapping procedures to estimate 95% CIs.[19] To examine the difference in total outpatient utilization between the 2 groups while controlling for other characteristics, a count data model was selected to account for distribution of the data. Using a chi-square goodness-of-fit test, a negative binomial regression model was selected over a Poisson regression model due to skewness and overdispersion.[20] Finally, the model was adjusted for individuals who died during FY 2008 by including an offset term for the length of time an individual was in the cohort. To examine the association between etiology of injury and cost, we used generalized linear models (GLM).[21-23]

In addition to injury etiology, both regression models included the following independent variables: gender, age, minority status, marital status, median household income (>1st quartile), comorbidities, rurality (urban, rural, highly rural), travel time to the nearest VA (>30 minutes), and level of injury (paraplegia, tetraplegia). Comorbidities considered for inclusion in the model were derived from the Charlson Comorbidity Index subscales. Subscales were included in the model if a minimum of 5% of the sample population were identified as having the comorbid condition (the subscale "paralysis" was not considered). Seven conditions were included: diabetes, peripheral vascular disease, myocardial infarction, congestive heart failure, chronic obstructive pulmonary disease (COPD), and chronic renal failure. In addition, a history or presence of pressure ulcers or depression was included. Comorbidities were calculated using data from FY 1999-2008 while all other predictors were obtained from 2008 data. Analyses were conducted in SAS version 9.1 (SAS Institute, Cary, North Carolina) and STATA SE version 11.0 (StataCorp LP, College Station, Texas).

Results

Veteran characteristics

The final cohort consisted of 8,645 veterans with traumatic SCI and 2,795 veterans with nontraumatic SCI/D. Injury classifications can be found in **Table 1**. Individuals identified as having a nontraumatic SCI/D were statistically significantly older with a greater number of comorbidities than veterans with traumatic SCI (see **Table 2**). Further, a greater proportion of veterans with nontraumatic SCI/D were female, married, urban dwelling, and non-white compared to those with traumatic SCI.

Table 1. Categorization of SCI/D etiology

	n	%
Traumatic[a]		
Motor vehicle accident	3,587	44.0
Fall	1,847	22.7
Act of violence	1,257	15.4
Other	955	11.7
Sports activity	498	6.1
Nontraumatic[b]		
Spondylosis/spinal stenosis	2,072	74.1
Infection	239	8.6
Tumor	129	4.6
Syringomyelia	123	4.4
Degeneration	114	4.1
Ischemia/vascular	104	3.7
Other specified congenital anomalies of the spinal cord	32	1.1
Myelitis	21	0.8
Spina bifida	18	0.6
Subacute combined degeneration of the spinal cord	7	0.3

Note: SCI/D = spinal cord injury/disorder.

[a]There were 501 individuals with traumatic SCI who were missing injury classification.

[b]Person included in each group if they ever had an *International Classification of Diseases, Ninth Revision* (*ICD-9*) code related to the category between fiscal year 1999 to 2008.

Utilization

Overall, veterans with nontraumatic SCI/D had statistically significantly higher OP utilization than veterans with traumatic SCI (17.97 vs 14.82, respectively; see **Table 3**). Specifically, individuals with nontraumatic SCI/D incurred more primary care, specialty care, and mental health encounters than those with traumatic SCI. In addition, veterans with nontraumatic SCI/D incurred a statistically significantly greater number of hospitalizations than those with traumatic injuries. The average length of stay, however, was not significantly different between the 2 groups. Veterans with traumatic SCI had statistically significantly greater outpatient utilization for only SCI center visits.

Table 2. Veteran demographics

	Traumatic (n=8,645)	Nontraumatic (n=2,795)	*P*
Age			
Mean (*SD*)	56.75 (13.16)	64.13 (11.85)	<.0001
Median (min-max)	57.81 (20-100)	62.67 (25-95)	
Male	97.8%	96.5%	.0001
Married	42.4%	47.9%	<.0001
Race			
White	76.4%	71.6%	<.0001
African American	18.7%	23.0%	
Other	2.2%	2.8%	
Unknown	2.8%	2.7%	
Ethnicity			
Hispanic	5.2%	6.0%	.0002
Not Hispanic	80.2%	82.5%	
Unknown	14.5%	11.5%	
Comorbidities			
Diabetes	20.2%	35.7%	<.0001
Peripheral vascular disease	7.2%	13.3%	<.0001
Myocardial infarction	4.5%	9.4%	<.0001
Congestive heart failure	5.1%	12.8%	<.0001
Cerebrovascular disease	5.2%	11.9%	<.0001
COPD	15.5%	28.3%	<.0001
Chronic renal failure	4.8%	8.6%	<.0001
Pressure ulcer	39.4%	18.0%	<.0001
Depression	44.3%	54.9%	<.0001
Rurality			
Urban	59.2%	62.9%	.0019
Rural	39.2%	35.5%	
Highly rural	1.6%	1.6%	
Median household income			
> 1st quartile	75.8%	72.8	.0015

Note: COPD = chronic obstructive pulmonary disease.

Diagnoses

The top 10 most frequently occurring IP and OP codes are found in **Table 4** and **Table 5**, after excluding *ICD-9* codes pertaining to paraplegia, tetraplegia, late effects of SCI, and automobile accidents. Overall, 6 of the top 10 IP diagnoses were shared by the traumatic and nontraumatic cohorts. The codes "follow-up exam," "cauda equina syndrome with neurogenic bladder," "pressure ulcer-lower back," and "pressure ulcer-hip" were unique to the traumatic cohort, whereas "esophageal reflux," "chronic airway obstruction," "coronary atherosclerosis of native coronary artery," and "tobacco use disorder" were unique to the nontraumatic cohort. Diagnoses of "UTI," "other psychosocial circumstances, not otherwise specified (NOS)," and "issue of repeat prescriptions" were found in the top 10 of only the traumatic cohort, whereas diagnoses of "diabetes," "lumbago," and "tobacco use disorder" were found in the top 10 of only the nontraumatic cohort.

Pharmacy

Veterans with nontraumatic SCI/D had statistically significantly more chronic medication fills than those with traumatic SCI (86.98 vs 72.82; number of 30-day supplies). There was no significant difference in number of acute medication fills. Of the top 10 medications, 8 were shared between veterans with traumatic and nontraumatic SCI/D with opiod analgesics accounting for the largest percent of prescriptions

Table 3. Utilization in fiscal year 2008

Type of care	Traumatic (n=8,645)	Nontraumatic (n=2,795)	*P**
Primary			
Mean (*SD*)	3.13 (5.73)	4.83 (7.97)	<.0001
Median (IQR)	1 (0-4)	3 (1-6)	
Range	0-94	0-199	
Visited in FY '08	67.6%	78.6%	
Speciality			
Mean (*SD*)	10.44 (14.47)	11.39 (15.94)	.0033
Median (IQR)	7 (3-13)	7 (3-15)	
Range	0-352	0-216	
Visited in FY '08	91.4%	89.4%	
Mental health			
Mean (*SD*)	1.38 (7.75)	2.58 (11.27)	<.0001
Median (IQR)	0 (0-0)	0 (0-1)	
Range	0-259	0-323	
Visited in FY '08	21.2%	30.2%	
SCI			
Mean (*SD*)	4.97 (11.33)	3.71 (9.94)	<.0001
Median (IQR)	2 (0-5)	0 (0-3)	
Range	0-333	0-150	
Visited in FY '08	72.6%	48.7%	
Rehab medicine			
Mean (*SD*)	2.15 (9.00)	2.44 (10.57)	.1547
Median (IQR)	0 (0-1)	0 (0-1)	
Range	0-232	0-209	
Visited in FY '08	40.4%	39.5%	
VA visit containing SCI center			
Mean (*SD*)	24.44 (58.12)	21.03 (48.85)	.0052
Median (IQR)	5 (0-17)	3 (0-19)	
Range	0-347	0-342	
Visited in FY '08	71.8%	58.0%	
Hospitalizations in FY '08			
Mean (*SD*)	0.79 (1.48)	0.92 (1.92)	.0001
Median (IQR)	0 (0-1)	0 (0-1)	
Range	0-21	1-19	
Visited in FY '08	40.6%	39.5%	
Length of stay			
Mean (*SD*)	41.97 (67.16)	44.76 (75.03)	.2437
Median (IQR)	13 (4-45)	13 (4-43)	
Range	1-354	1-334	
Outpatient visits in FY '08[a]			
Mean (*SD*)	14.82 (18.56)	17.97 (21.30)	<.0001
Median (IQR)	9 (4-18)	12 (5-23)	
Range	0-340	0-239	
Visited in FY '08	96.6%	96.1%	

Note: FY = fiscal year; IQR = interquartile range; SCI = spinal cord injury; VA = Veterans Affairs

[a]Visit considered stop at primary or specialty care, SCI or traumatic brain injury (TBI) clinic, mental health, or rehab medicine.

**P* value calculated using one-way analysis of variance (ANOVA) of the means.

Table 4. Top 10 inpatient diagnoses per patient and overall[a]

	Traumatic (n=8,645)					Nontraumatic (n=2,795)				
		Per patient		Overall			Per patient		Overall	
	ICD-9 code	n	%	Count	%	*ICD-9* code	n	%	Count	%
1	Neurogenic bowel	2,185	25.3	3,176	5.4	Hypertension	567	20.3	906	4.3
2	Neurogenic bladder	2,050	23.7	3,119	5.3	Neurogenic bladder	429	15.3	701	3.3
3	UTI	1,359	15.7	2,557	4.3	Neurogenic bowel	416	14.9	649	3.1
4	Hypertension	1,164	13.5	1,731	2.9	UTI	347	12.4	691	3.3
5	High cholesterol	705	8.2	927	1.6	Diabetes	310	11.1	564	2.7
6	Follow-up exam	700	8.1	1,179	2.0	High cholesterol	293	10.5	398	1.9
7	Cauda equina syndrome, with neurogenic bladder	697	8.1	932	1.6	Esophageal reflux	175	6.3	240	1.1
8	Diabetes	669	7.7	1,132	1.9	Chronic airway obstruction	164	5.9	298	1.4
9	Pressure ulcer - lower back	554	6.4	1,037	1.8	Coronary atherosclerosis of native coronary artery	154	5.5	261	1.2
10	Pressure ulcer - hip	401	4.6	734	1.2	Tobacco use disorder	149	5.3	198	0.9

Note: UTI = urinary tract infection.

[a]Overall calculated as the sum of the specified *ICD-9* code divided by all *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes used in fiscal year 2008.

Table 5. Top 10 outpatient diagnoses per patient and overall[a]

	Traumatic (n=8,645)					Nontraumatic (n=2,795)				
		Per patient		Overall			Per patient		Overall	
	ICD-9 code	n	%	Count	%	*ICD-9* code	n	%	Count	%
1	Neurogenic bladder	4,708	54.5	19,221	6.0	Hypertension	1,396	49.9	5,385	3.9
2	Neurogenic bowel	3,339	38.6	11,415	3.6	Influenza vaccination	970	34.7	1,043	0.7
3	Influenza vaccination	2,815	32.6	2,992	0.9	Other specified counseling	897	32.1	3,288	2.4
4	Counseling	2,739	31.7	8,450	2.6	Neurogenic bladder	896	32.1	3,785	2.7
5	Hypertension	2,614	30.2	8,557	2.7	Counseling	893	31.9	3,034	2.2
6	Other specified counseling	2,407	27.8	7,600	2.4	High cholesterol	856	30.6	2,022	1.4
7	UTI	2,014	23.3	5,070	1.6	Diabetes	772	27.6	4,546	3.3
8	High cholesterol	1,951	22.6	4,294	1.3	Lumbago	590	21.1	1,826	1.3
9	Other psychosocial circumstance, NOS	1,555	18.0	3,334	1.0	Neurogenic bowel	535	19.1	2,078	1.5
10	Issue of repeated prescriptions	1,509	17.5	5,081	1.6	Tobacco use disorder	492	17.6	1,223	0.9

Note: UTI = urinary tract infection; NOS = not otherwise specified.

[a]Overall calculated as the sum of the specified *International Classification of Diseases, Ninth Revision* (*ICD-9*) code divided by all *ICD-9* codes used in fiscal year 2008.

Table 6. Top 10 outpatient prescription pharmacy fills per patient and overall[a]

	Traumatic (n=8,645)					Nontraumatic (n=2,795)				
		Per patient		Overall			Per patient		Overall	
	VA class	n	%	Count	%	VA class	n	%	Count	%
1	Opiod analgesics	3,509	40.6	34,426	8.3	Opiod analgesics	1,299	46.5	13,340	8.7
2	Benzodiazepine derivative sedatives/ hypnotics	2,736	31.6	22,247	5.4	Antidepressants[b]	1,024	36.6	7,675	5.0
3	Dermatologicals, topical other[c]	4,121	47.7	21,907	5.3	Anticonvulsants	1,061	38.0	7,082	4.6
4	Skeletal muscle relaxants	3,262	37.7	19,736	4.8	Antilipemic agents	1,316	47.1	5,817	3.8
5	Anticonvulsants	2,419	28.0	15,529	3.7	Skeletal muscle relaxants	982	35.1	5,734	3.7
6	Antidepressants[b]	2,431	28.1	15,522	3.7	Non-opiod analgesics	1,207	43.2	5,234	3.4
7	Laxatives, rectal	2,990	34.6	14,003	3.4	Benzodiazepine derivative sedatives/hypnotics	616	22.0	4,800	3.1
8	Antilipemic agents	2,923	33.8	12,304	3.0	Gastric medications, other	1,084	38.8	4,467	2.9
9	Non-opiod analgesics	2,881	33.3	11,416	2.7	Beta blockers/related	924	33.1	3,896	2.5
10	Gastric medications, other	2,654	30.7	10,978	2.6	ACE inhibitors	870	31.1	3,469	2.3

Note: ACE = antiotensin-converting enzyme.

[a]Overall calculated as the sum of the specified *International Classification of Diseases, Ninth Revision* (*ICD-9*) code divided by all *ICD-9* codes used in fiscal year 2008.

[b]Antidepressants excludes monoamine oxidase inhibitors (MAOIs) and tricylics.

[c]Dermatologics, topical other includes items such as powders (baby, talc, etc), lubricants, mineral oils, lotions, ointments, and minoxidil.

Table 7. Regression models examining outpatient utilization and total health care cost

Parameter	Outpatient utilization: IRR (95% CI)	Outpatient utilization: *P*	Outpatient utilization: Percent change	Total health care cost: $ Change (95% CI)	Total health care cost: *P*
Male	0.91 (0.81, 1.02)	.092	-9.1%	1,291 (-6,437, 9,018)	.743
Age ≥ 65	0.98 (0.94, 1.03)	.456	-1.6%	2,692 (-1,075, 6,459)	.161
Racial minority[a]	1.13 (1.09, 1.18)	<.001	13.2%	6,052 (1,610, 10,494)	.008
Married	1.04 (1.01, 1.08)	.018	4.4%	-3,531 (-6,759, 304)	.033
Income >1st quartile	0.91 (0.87, 0.95)	<.001	-8.9%	-840 (-4,446, 2,765)	.648
Comorbidities					
Diabetes	1.18 (1.13, 1.23)	<.001	17.8%	15,477 (11,288, 19,667)	<.001
Peripheral vascular disease	1.12 (1.05, 1.20)	<.001	12.1%	5,035 (-157, 10,227)	.057
Myocardial infarction	1.10 (1.02, 1.19)	.016	10.0%	7,086 (-1,171, 15,343)	.093
Congestive heart failure	1.10 (1.03, 1.19)	.009	10.3%	14,182 (6,195, 22,170)	.001
Cerebrovascular disease	1.03 (0.96, 1.11)	0.366	3.3%	9,014 (1,573, 16,454)	.018
COPD	1.08 (1.04, 1.13)	.001	8.3%	11,555 (7,147, 15,963)	<.001
Chronic renal failure	1.28 (1.18, 1.38)	<.001	27.8%	26,501 (17,627, 35,374)	<.001
Pressure ulcer	1.25 (1.20, 1.30)	<.001	24.9%	47,950 (43,938, 51,962)	<.001
Depression	1.38 (1.33, 1.43)	<.001	37.8%	12,346 (9,058, 15,633)	<.001
Rurality					
Rural (1) vs Urban (0)	0.78 (0.75, 0.82)	<.001	-21.8%	-7,368 (-10,753, -3,983)	<.001
Highly Rural (1) vs Urban (0)	0.63 (0.54, 0.73)	<.001	-37.2%	-10,952 (-18,527, -3,377)	.012
Travel time > 30 minutes	0.72 (0.69, 0.74)	<.001	-28.5%	-12,567 (-16,392, -8,742)	<.001
Level of injury	0.72 (0.69, 0.74)	<.001	-28.5%	-12,567 (-16,392, -8,742)	<.001
Paraplegia (1) vs Tetraplegia (0)	0.97 (0.94, 1.01)	.110	-2.9%	-12,981 (-16,529, -9,433)	<.001
Missing (1) vs Tetraplegia (0)	0.99 (0.879, 1.112)	.854	-1.1%	-24,927 (-29,266, -20,588)	<.001
Nontraumatic etiology	1.14 (1.09, 1.19)	<.001	13.9%	1,108 (-3,029, 5,244)	.600

Note: IRR = incidence rate ratio; COPD = chronic obstructive pulmonary disease.

[a]Racial minority includes individuals identified as non-white.

filled (see **Table 6**). Unique to the traumatic cohort were topical dermatologicals and rectal laxatives, while cardiovascular drugs (beta blockers and ACE inhibitors) were unique to the nontraumatic cohort.

Regression analyses: total outpatient encounters

Veterans with nontraumatic SCI/D had more OP encounters than those with traumatic SCI after controlling for a set of covariates identified previously (P < .001; see **Table 7**). A statistically significant increase in OP encounters was found among minorities compared to whites (P < .001) and married individuals compared to those who were not married (P < .018). With the exception of cerebrovascular disease, the presence of any comorbid condition, including pressure ulcer(s) or depression, significantly increased the total number of OP encounters.

A decrease in OP utilization was found when median household income was above the first quartile (P < .001) and when veterans had to travel greater than 30 minutes to the nearest VA (P < .001). Additionally, veterans living in rural (P < .001) or highly rural (P < .001) settings had significantly less utilization than urban dwelling veterans. OP encounters did not differ by gender, age (≥65 years), or level of injury.

A subanalysis of the regression model above adding the variable "time since injury" was conducted examining veterans with traumatic SCI only. Veterans with nontraumatic SCI/D were excluded as injury onset date is frequently missing (>40%). Less OP utilization was found when time since injury was greater than 5 years (P < .001) or when time since injury was missing (P < .001) compared to veterans incurring an injury in the last 5 years.

Regression analyses: total adjusted cost

Injury etiology (traumatic vs nontraumatic) was not a statistically significant predictor of total cost after controlling for covariates (see **Table 7**). A statistically significant increase in total cost was found among racial minorities (P = .008) and when the presence of any comorbid condition, including pressure ulcer(s) and depression, were present, with the exception of myocardial infarction and peripheral vascular disease.

A decrease in total cost was found among married veterans (P = .033) and those living in rural (P < .001) or highly rural (P = .012) settings compared to urban dwellers. Veterans with an injury level of paraplegia (P < .001) or a missing injury level (P < .001) incurred significantly lower total cost than veterans with a tetraplegic level of injury. Neither injury etiology (traumatic vs nontraumatic), gender, age (≥65 years), nor median household income were significant predictors of total cost.

Total unadjusted cost

Veterans with traumatic or nontraumatic SCI/D did not differ in total incurred health care costs during FY 2008 ($49,106 vs $45,470 respectively; see **Table 8**). Further, groups did not differ on total OP, total pharmacy, or total IP costs. Veterans with nontraumatic SCI/D did incur significantly higher costs for OP primary and mental health care, IP acute care, and nonacute IP mental health and long-term care days. Veterans with traumatic SCI had significantly higher costs associated with "other" OP encounters (eg, telephone, laboratory, and other ancillary services) as well as nonacute IP SCI days. When veterans were admitted to a non-VA facility paid for by VA, associated costs were significantly higher for those with nontraumatic ($1,479) than traumatic ($877) SCI.

A subanalysis of veterans who died during FY 2008 (n = 674) had statistically significantly higher unadjusted total costs ($78,325) than those who did not die during the study period ($46,333). Additionally, veterans with recent, traumatic SCI/D had significantly higher unadjusted total costs than those with older injuries: less than or equal to 1 year post injury (n = 172; $88,502 vs $48,307; P < .001) or less than or equal to 5 years post injury (n = 1,182; $59,794 vs $48,839; P = .0003).

Discussion

When compared to veterans with traumatic injuries, veterans with nontraumatic SCI/D in our cohort were older, lived in more urban settings,

Table 8. Health care costs in fiscal year 2008 among veterans with traumatic (N=8,645) and nontraumatic (N=2,795) SCI/D (in US dollars) START

	Traumatic	Nontraumatic	
Encounter	**Mean Median (IQR)**	**Mean Median (IQR)**	**Difference (95% CI)**
Outpatient care			
Primary care	902 305 (0-937)	1,370 607 (101-1,474)	468 (365, 602)
Mental health	309 0 (0-7)	508 0 (0-245)	200 (136, 289)
Special care	7,694 4,270 (1,689-9,085)	7,045 3,424 (1,064-8,270)	-649 (-1,165, 248)
Other outpatient	7,751 3,908 (1,832-8,562)	6,937 3,836 (1,643-8,282)	-814 (-1,282, -371)
Total outpatient costs	16,655 10,570 (5,065-20,814)	15,860 10,339 (4,586-20,194)	-796 (-1,637, 379)
Outpatient pharmacy			
Chronic medications	1,826 861 (291-1,930)	1,886 1,054 (320-2,331)	60 (-96, 224)
Acute medications	112 14 (0-72)	143 15 (0-74)	32 (1-86)
Total pharmacy costs	1,938 928 (330-2044)	2,030 1,135 (360-2460)	91 (-68, 288)
Inpatient care			
Acute VA hospital days	3,341 0 (0-0)	4,460 0 (0-0)	1119 (407, 2,631)
Nonacute VA hospitalizations			
Rehabilitation days	114 0 (0-0)	176 0 (0-0)	62 (-48, 268)
SCI days	19,394 0 (0-5,389)	11,752 0 (0-0)	-7,642 (-9,899, -5,334)
Mental health days	233 0 (0-0)	520 0 (0-0)	286 (88, 572)
ICU days	2,526 0 (0-0)	2,426 0 (0-0)	-99 (-799, 642)
Long-term care days	3,534 0 (0-0)	6,299 0 (0-0)	2753 (1,419, 4,271)
Other nonacute care days	483 0 (0-19)	470 0 (0-11)	-14 (-137, 134)
Non-VA hospital days financed by VA	877 0 (0-0)	1,479 0 (0-0)	602 (278, 933)
Total inpatient costs	30,513 0 (0-16,352)	27,581 0 (0-16,131)	-2932 (-5,988, 534)
Total health care costs	49,106 18,296 (7,824-46,820)	45,470 18,476 (7,440-4,4304)	-3636 (-7,288, 199)

Note: SCI/D = spinal cord injury/disorder; IQR = interquartile range; VA = Veterans Affairs; ICU = intensive care unit.

and were more likely to be female and have a comorbid condition. Because many of the causes of nontraumatic injuries are associated with age, it is not surprising that the average age and frequency of comorbidities is higher for veterans with nontraumatic versus traumatic injuries, and these findings are consistent with several previous studies.[6,7,24-27] Although the number of female veterans with SCI/D is small compared to the number of male veterans, the percentage of female veterans was significantly higher in the nontraumatic group, which is also consistent with previous findings.[6,24-29] There is conflicting evidence within the literature surrounding the proportion of minorities/African Americans with traumatic and nontraumatic SCI/D. Some studies report no differences,[26,27] whereas others, including the current study, find a greater proportion of African American veterans with nontraumatic SCI/D.[29] These differences may exist due to differences in sample sizes and/or patient populations and should be explored in future research. Yu and colleagues found increased comorbidities among veterans compared to the general population,[30] and the same pattern is found among veterans with SCI/D compared to the general SCI population.[6]

Consistent with prior studies, traumatic SCI was typically related to motor vehicle accidents followed by falls and acts of violence.[7,24] Comparison of nontraumatic SCI/D causes is complicated by lack of a universal definition of nontraumatic SCI/D, as well as the potential for multiple disorders to co-occur (eg, spondylosis and spinal stenosis). Prior research has included a wide range of disorders or disorder groupings that are often poorly defined.[24-26,29,31-33]

Travel time and rurality are known barriers to health care access[34]; in the current study, travel time of more than 30 minutes and residence in a rural or highly rural setting significantly reduced utilization and cost. This finding coincides with work by LaVela et al[35] who found increased travel distance to be negatively associated with IP/OP utilization among veterans with SCI/D. Travel time in this study was calculated to the nearest facility; however, veterans often bypass the closest facility to use a hospital with an SCI facility.[35] As such, the actual effect of travel time may be underestimated in the current findings.

As expected, the most common conditions found in both cohorts were neurogenic bowel and bladder, urinary tract infection (UTI), diabetes, and hypertension. These conditions are commonly reported in other studies.[7,24,26,31,36,37] Unlike the nontraumatic cohort, veterans with traumatic SCI had IP diagnoses of pressure ulcers, which have been shown to occur more frequently in individuals with traumatic versus nontraumatic SCI/D[24,26] and are most likely attributable to nontraumatic injuries/disorder being lower, incomplete lesions of the spinal cord.[38]

There is limited information describing medication patterns for individuals with chronic SCI. Chronic pain among individuals with SCI/D is well documented[39-42] and is reflected in this study by the frequent use of opiod analgesics (accounting for over 8% of all outpatient prescriptions filled). The major difference in medication use between veterans with traumatic and nontraumatic injuries was the use of cardiovascular medicines in the nontraumatic group. One possible explanation for this difference includes the older age of veterans with nontraumatic injuries.

Literature comparing the costs of individuals with traumatic and nontraumatic SCI/D is limited, however they provide context for the current findings. French et al estimated that the mean direct health care costs for a cohort of 675 veterans with SCI/D in 2005 was $21,450.[43] Their sample of veterans was from 3 regional VA systems and excluded individuals who were ventilator dependent, on bed rest for more than a month, or who had durations of injury less than 2 years. In a comparison of costs incurred by veterans with chronic conditions, veterans with SCI had the highest mean costs of $26,735 per year, while veterans with arthritis incurred $6,075 in total costs and veterans with renal failure incurred $22,656.[30] In a study of veterans over the age of 65, veterans with SCI incurred a mean cost of $31,306, compared to veterans without any chronic conditions who had a mean total cost of $1,482.[44] Finally, Yu et al estimated costs during the last 2 years of life.[45] In the final year before death, the average costs incurred by veterans with SCI/D were $61,900, compared to $24,900 in the second year before end of life.[45] This is consistent with our subanalysis indicating costs were higher for veterans who died during the year. Although the estimates of mean costs in the literature vary because of differences in sample selection, time, and costs included, both the findings in this study and in the literature demonstrate the substantial health care needs of individuals with SCI/D.

Most studies of neurotrauma costs and health care utilization have focused on acute rehabilitation. A number of these studies have found associations between cost and level or etiology of injury. In a study of rehabilitation charge outliers in private sector hospitals, Burnett et al found that higher charges were associated with higher levels of injuries, the extent of the injury, the presence of pressure ulcers, and other medical complications.[46] A study of 115 persons with SCI/D found that the length of initial hospitalization was associated with injury severity, but that length of readmissions was not. Total charges for the first 2 follow-up years were associated with level of injury.[47] DeVivo et al concluded that mean annual medical charges for persons with SCI/D differed based on the etiology of the injury, possibly because the types of injuries associated with certain etiologies differ.[48] Age and the number of years post injury were associated with annual follow-up costs in a study of patients in Craig Hospital.[49] In a study of costs and lengths of stay for rehabilitation, Cifu et al found that older ages resulted in longer length of stay and total hospital charges.[49,50] Differences in health care systems, and in methods, may account for the variation in results.

There are several limitations to these data. Retrospective studies that rely on administrative data are limited by missing data (ie, as in the SCD registry) and by inaccurate coding of diagnoses. However, previous analyses have shown that coding for the VA medical data sets is fairly reliable.[51] Additionally, cost information on prosthetic use was not included, and we were unable to address health care utilization outside of the VA when veterans use private insurance, Medicare, or Medicaid. Future studies should incorporate Medicare and Medicaid data for a more exact estimate of health care costs for veterans with SCI/D. Because the sample contains only veterans and all data are derived from VA sources, generalizability may be limited; however, the types of diagnoses have been noted and should provide insight to those receiving care at a non-VHA facility. Due to the relatively large sample size, some findings, although statistically significant, may not be clinically meaningful whereas other findings may be underpowered (ie, ICU days). Finally, our estimates do not include veterans who were missing demographic information (n = 425), who exclusively used fee basis services (n = 71), or who had no utilization in FY 2008. Veterans with no utilization would incur zero cost and decrease our estimates, but the inclusion of veterans exclusively using fee basis services may inflate or deflate estimates. It is likely that the inclusion of veterans with missing demographics would decrease cost estimates as those missing demographic information had lower utilization. This study was designed to provide an overview of the differences between the individuals with traumatic and nontraumatic SCI/D who received care through this system; future studies will provide additional information about how chronic disease is managed and what the primary cost drivers are for this population to ensure that the best ways to manage SCI/D are indentified.

Conclusion

As the largest system of care in the world for individuals with SCI/D, and as a leader in the use of electronic medical record, the VHA provides a unique opportunity to examine the costs and utilization patterns of veterans with SCI/D. Our findings indicate that veterans with nontraumatic SCI/D have greater overall OP utilization; however, the overall health care costs between traumatic and nontraumatic SCI/D were not statistically significantly different. Future research should explore interventions to prevent secondary complications aiming to decrease costs and improve health status (eg, preventing pressure ulcers, improving pain management, etc). Additionally, a more thorough understanding of travel barriers and the effect of home care, telehealth, and other strategies to address potential barriers to access in this patient population should be examined.

Acknowledgments

This study was supported by grant IIR 07-188-3 from the US Department of Veterans Affairs, Office of Research and Development, Health Services Research and Development Service. The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the US government.

We would like to thank doctors Sunil Sabharwal, Helen Hoenig, Yvonne Lucero, Shanti Ganesh, Radhika Rao, and Jan Prentice, PA-C, for their assistance in reviewing and classifying traumatic and nontraumatic SCI/D *ICD-9* codes.

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Cost of Rehabilitation Care in Traumatic and Nontraumatic Spinal Cord Injury in a European Context

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In 2005-2007, a study was performed together with the Belgian Health Care Knowledge Centre (KCE) to assess the current financial rehabilitation agreements and the organization and financing of musculoskeletal and neurological rehabilitation in Belgium and to make recommendations for improvement. Five pathologies, including spinal cord injury (SCI), were selected for analysis and cost estimation. These data were completed with a cost analysis of 4 SCI patients admitted at the Rehabilitation Centre UZ Leuven. Finally, a 3-level stratified rehabilitation model was recommended, based on a patient classification system. SCI should be treated in the highly specific (third) level. **Key words:** *Belgium, Europe, health care costs, organization, rehabilitation, spinal cord injuries*

In European countries, the estimated incidence of spinal cord injury (SCI), traumatic (T-SCI) and nontraumatic (NT-SCI) combined, ranges from 1.04 to 2.97 per 100 000 inhabitants, which is lower than in most other continents.[1,2] Incidence is consistently higher for men than for women.[3,4] In the majority of the cases, the etiology is traumatic.[5] SCI appears mostly in the age interval from 33 years to 50 years.[4,6] For T-SCIs, the mean age is about 29 years.[7,8] In the United States since 2005, the mean age at T-SCI is 40 years; a higher percentage of cervical and incomplete injuries as well as a higher relative incidence of falls has been described, especially in recent years.[9-11] All this seems to be in agreement with demographic ageing. In a recent systematic review on the incidence of SCI worldwide, van den Berg drew the same conclusion.[12] In T-SCI, 2 age peaks were discerned: between the age of 15 and 29 and in people aged 65 or older. In NT-SCI, incidence rate increased steadily with age. In his review, European incidence (of T-SCI) was 1.21, 1.94, and 5.78/100,000 inhabitants, respectively, for The Netherlands, France, and Portugal.

An SCI is a devastating event with important medical and functional consequences, which suggests a high direct cost. To our knowledge, no databases with specific data on SCI are available in the different European countries. Also, literature concerning costs in Europe is scarce. A European collaborative effort called the EUROCOST project studied the burden of injury in 6 European countries.[13] They stated that, together with skull-brain injuries, SCI resulted in the highest total years lived with disability (YLD; 82.6) due to lifelong disability in a relatively young patient group. SCI also had the highest global burden of disease weight (0.725) with a lifelong duration (World Health Organization [WHO] Global Burden of Disease study).[14] In 2005, Polinder made an estimation of the direct medical costs of injury-related hospital admissions in 10 European countries, including 28 injury groups.[15] Vertebral column/spinal cord injury ranked 13th in incidence (0.5/1000) but fifth in cost per capita (€1.11) and in mean costs (€3,305). A study of the incidence and health care costs including long-term care of injuries in The Netherlands, published in 2006, estimated the health service use and costs per patient group in a prospective study among 5,755 injured patients.[16] Vertebral column/spinal cord injury ranked 7th, accounting for 3.8% of the total cost in 1999 (€1.15 billion), in contrast with ranking 21st for incidence with 0.6% of the

Top Spinal Cord Inj Rehabil 2011;16(4):43–52

doi: 10.1310/sci1604-43

injuries. The mean cost per patient ranked fourth, with €6,600 per patient.

In this article, the costs of rehabilitation are discussed from a Belgian perspective. Belgium is a small, though densely populated, country with approximately 10.8 million inhabitants, the total being 501.1 million for the 27 European Union-member states.[17] Between October 2005 and July 2007, we performed, in close collaboration with the Belgian Health Care Knowledge Centre (KCE), a study ordered by the government.[1] The aims were to assess the current Belgian organization and financing system of musculoskeletal and neurological rehabilitation (MNR) and to make proposals and recommendations for rationalization and improvement. First, an analysis of the current financing system of SCI rehabilitation in Belgium will be presented, and then an estimation will be made of the financial burden of SCI rehabilitation in Belgium. These data are primarily based on assumptions and are limited to the cost of rehabilitation activities in the postacute phase, which starts early (usually a couple of weeks) after the acute phase and comprises the inpatient as well the outpatient rehabilitation. As defined for *International Classification of Functioning, Disability and Health* (ICF) core set purposes, the early postacute context covers the first comprehensive rehabilitation after the acute SCI, which is followed by the long-term context.[18] SCI leads to lifelong disability, so maintenance care and therapy, complications, or new phases in life (such as ageing) may induce substantial supplementary costs. As data concerning the long-term phase are not available in Belgium, this phase will not be addressed. Third, the direct cost of 4 SCI cases is described with regard to the entire hospitalization episode following an acute SCI to test the assumptions in the KCE report. The setting is the Rehabilitation Centre of the University Hospitals of Leuven campus Pellenberg. Four patients were selected from a cohort of 68 patients who were admitted in 2008-2009. They were selected taking into account level of lesion (paraplegia/tetraplegia) and etiology (T/NT). Finally, data of a comparative study of 5 countries are described.[1] Based on the results of the different analyses and the international comparison, recommendations concerning the organization and financing of SCI rehabilitation in Belgium are made as a potential model for other countries.

Methods

Analysis of the current financing system of SCI rehabilitation in Belgium

Five pathologies (including SCI) were selected for the analysis, representing about 75% of the case mix in Belgian MNR. For these pathologies, clinical pathways were studied in literature. When scientific data were lacking, the study was completed using grey literature, data obtained from the National Institute for Health and Disability Insurance (NIHDI), and the Belgian sickness funds.[1] NIHDI is a public institution responsible for the administration, supervision, and financial management of sickness and invalidity insurance. It receives contributions from the National Office of Social Security and passes them on to the payments institutions (the various sickness funds). Then, by means of expert meetings and surveys, the actual clinical practice in Belgium was analyzed.

Estimation of the financial burden of SCI rehabilitation in Belgium

Direct cost (using 2006 Euro values) of rehabilitation care of T-SCI and NT-SCI was calculated in 3 different perspectives: (1) costs to rehabilitation providers, (2) payments NIHDI made to rehabilitation providers (expenses), and (3) payments rehabilitation providers received (revenues). This part of the study only considers the cost for the postacute rehabilitation activities (inpatient + outpatient phase) and does not take into account any other costs, such as for hospitalization services, technical investigations, or pharmacy.[1] First, personnel costs and an overhead cost per patient hour were calculated. Then, cost for an average SCI patient and total cost for SCI rehabilitation in Belgium were estimated using standard rehabilitation protocols (describing intensity and duration of therapy) and were compared with the current reimbursement system.

Personnel cost

Using annual wage cost (15 years seniority) for medical and paramedical (7 categories) input and accounting for the number of working hours per year, it is possible to calculate the cost of 1 hour of input. The theoretical hourly wage cost combined with total number of hours input, based on the experts' protocols as defined later, reflect the total staff costs for rehabilitation activities.

Overhead cost per patient hour

Nine rehabilitation centers were asked to fill in a template to provide data on (1) medical and paramedical staff; (2) operating expenses, depreciations, and overhead; (3) surface area of the rehabilitation centre (inpatient ward and rehabilitation rooms); and (4) annual activities, such as number of rehabilitation sessions within nomenclature or conventions.

Four templates were returned, one of which was incomplete and could not be used. The overhead cost for a patient hour of rehabilitation was calculated by allocating the total operating costs (excluding wages) and depreciation costs of general overhead costs to the respective surface areas.

Total cost, revenues, and expenditures

Because evidence-based literature on postacute rehabilitation needs in terms of intensity and duration were very limited, costs, revenues, and expenditures were estimated based on rehabilitation protocols for paraplegia and tetraplegia as defined by 7 experts. These experts determined a reference rehabilitation protocol for an average patient, specifying the following:

- the number of weeks treatment is needed
- the number of hours per week a medical rehabilitation specialist is involved
- the number of sessions per week of paramedical input (subdivided into individual and group activities and into the type of disciplines involved, ie, physical therapy, occupational therapy, speech therapy, social work, sports therapy, nursing, and psychology)

These proposed rehabilitation protocols were subjective/empirical estimates and were not based on scientific data. This methodology has also been used in the HealthBASKET study by the European Commission.[19]

Theoretical revenues of the centres and NIHDI expenses for the average SCI rehabilitation programs according to the protocols defined by the experts are estimated by applying the current reimbursement mechanisms in Belgium. Given that SCI can be treated within 3 different reimbursement systems, 3 scenarios were built to estimate the range of likely revenues. The revenues are calculated using full prices (applicable in January 2007) covering the reimbursement tariff as well as the patient out-of-pocket payment.

Then, the global costs, rehabilitation centre revenues, and health authorities' expenditures for SCI (postacute phase) in Belgium are calculated for average SCI inpatients and outpatients. The estimation of the Belgian total budget of SCI postacute rehabilitation during 1 year is based on a hypothetical 200 patients (100 with paraplegia and 100 with tetraplegia, based on the extrapolation of European epidemiological data).

Illustrative cases

In 2008-2009, 68 patients were admitted to the Rehabilitation Centre UZ Leuven, of which 53 were injured recently and 15 cases were readmissions. Of the 53 postacute patients, 5 had an oncological etiology and were excluded. Of the remaining 48 patients, 15 presented with tetraplegia and 33 with paraplegia. The mean age at injury was 53 years (51 for T-SCI, 58 for NT-SCI). Half of the patients were referred in the postacute phase from other hospitals, the other half stayed at UZ Leuven during the acute as well as the postacute (rehabilitation) phases. For a detailed analysis, 4 representative patients were selected (**Table 1**): 2 men and 2 women, 2 paraplegics and 2 tetraplegics, 2 with a traumatic and 2 with a nontraumatic etiology. Two of the patients stayed at UZ Leuven from the onset till the end of the rehabilitation phase. Two others only stayed there for postacute clinical rehabilitation.

The direct medical cost during hospitalization has been calculated, including all costs directly related to the health care intervention under

Table 1. Illustrative case studies

Patient	Gender	Age at injury	Level of injury	AIS	A+PA/PA	Etiology	LOS acute	LOS PA	FIM adm	FIM disch
1	F	35	C6	C	A+PA	T	12 d	12 m	48	72
2	F	65	T12	B	A+PA	NT (intraspinal hematoma)	16 d	6 m	78	124
3	M	63	C7	B	PA	NT (epidural hematoma)		5 m	68	84
4	M	27	T11	A	PA	T		4 m	66	110

Note: M = male; F = female; A = acute phase; PA = postacute phase; T = traumatic etiology; NT = nontraumatic etiology; LOS = length of stay; AIS = ASIA Impairment scale; FIM adm = FIM score at admission at the rehabilitation center; FIM disch = FIM score at discharge from the rehabilitation center.

consideration such as costs of hospitalization (bed day-price), pharmacy, imaging or laboratory exams and procedures, rehabilitation therapy, and physicians' honoraries.[20] After discharge, the patients were referred to regional centers for the ambulatory phase. Therefore, the cost of outpatient rehabilitation was not included.

International comparison

Chapter 8 of the KCE report describes an international comparative study of 5 countries: France, Germany, The Netherlands, Sweden, and the United States.[1] The following research questions were studied:

- How is (postacute) MNR organized and financed?
- What are the current health service debates and organization models and are there any specific quality initiatives taken related to postacute MNR?
- Can anything be learned about the organizational choices made in these countries for the current Belgian debate on postacute MNR?
- What choices are made for the selected pathology groups?

Results

Analysis of the current financing system

A detailed analysis of the organization and financing systems of MNR in Belgium showed that the current system lacks transparency and clinical coherence: several parallel payment systems exist, but they are primarily based on historical evolutions rather than on criteria related to patients' rehabilitation needs and goals.

One payment system is linked to hospital stay in different kinds of beds with variable financing systems. Postacute rehabilitation usually takes place in specialized beds (Sp-beds) for treatment and rehabilitation of musculoskeletal and neurological disorders. However, some centres perform rehabilitation activities in other bed types (eg, acute or psychiatric beds). The equivalent of the day-price, called budget of financial means (BFM), varies to a significant extent between institutions.

Other payment systems for the reimbursement of SCI patients are linked to rehabilitation activities and concern nomenclature (K30/45/60) and rehabilitation agreements, also called conventions (9.50 and 7.71). These are financial agreements between a health care provider and the national health insurance concerning specific diagnostic groups. A 9.50 convention is a generic agreement between NIHDI and a health care provider covering 10 diagnostic groups including acquired paraplegia or tetraplegia. The 7.71 convention is a specific agreement that can also cover SCI. Rehabilitation nomenclature is part of the nomenclature for medical interventions and is paid by means of (physicians') honoraries: K30/45/60 covers multidisciplinary treatment for pathologies on a limitative list (including SCI). All

Table 2. Prices of the different rehabilitation fees

Payment system	Intensity	Price October 2010
K 60 (nomenclature, max 120 sessions)	2 hours/day	€66,45 (€33,26/h)
R 60, convention 9.50 the first 6 months	2 hours/day	€66,45 (€33,26/h)
Convention 9.50, month 6 to 24	Not defined	€44,59
Convention 7.71, half day Paraplegia max 9, tetraplegia max 15 months	2.5 hours	€82,51 (€33,00/h)
Convention 7.71, full day Paraplegia max 9, tetraplegia max 15 months	5 hours	€151,92 (€30,38/h)

systems are mainly fee-for-service systems with a set price for a certain number of hours per day of multidisciplinary treatment. **Table 2** shows the current value of these fees. For more details, we refer to chapter 5 of the KCE report.[1]

Several combinations and accumulations of the different payment systems are possible, inducing a very heterogeneous rehabilitation landscape in Belgium. Moreover, the different payment systems overlap significantly; for example, treatment of SCI, stroke, or multiple sclerosis can be reimbursed with each payment system. There are no clear criteria for patient referral to the different types of rehabilitation organizations, and the only limiting characteristic is medical diagnosis. There are no criteria justifying inpatient treatment nor are patients' rehabilitation needs and goals formally assessed.

The NIHDI expenditures for MNR accounted for 0.38% of the health care budget in 2000 and 0.48% in 2004. In absolute figures, the expenditure for MNR in Belgium grew about 50% between 2000 and 2004 (from €57.3 million to €87.4 million). Unfortunately, it is impossible to estimate the part of this budget spent for patients with SCI.

Estimation of the financial burden

Personnel costs

The approximate cost per hour for the different disciplines in 2006 was as follows:

- Medical input:
  - —Rehabilitation specialist (salaried): €74.05/hour
- Paramedical input:
  - —Physical therapist, psychologist, sports therapist, social worker (all master's level): €39.26/hour
  - —Occupational therapist, social worker, nurse, speech therapist (all bachelor's level): €30.44/hour

An increasing number of speech therapists obtain a master's degree, so this cost is probably underestimated.

Overhead cost per patient hour

Dividing operating costs, depreciations, and overhead costs allocated to rehabilitation rooms by their annual use (measured in patient hours) for the 3 centers leads to an overhead cost per patient hour of, respectively, €12.44, €15.62, and €25.51 per hour.

Total cost, revenues, and expenditures

Table 3 shows staff costs completed with the allocated overhead costs for the rehabilitation protocols.

For comparative purposes, the total costs borne by the rehabilitation centres for each rehabilitation protocol, assuming an overhead cost of €15/hour, are presented in **Table 4**. This comparison shows that in all reimbursement systems, the theoretical costs are significantly higher than the revenues.

In addition, an attempt was made to estimate the total costs, revenues, and expenses for the rehabilitation of postacute rehabilitation of SCI patients (per year). The calculation was based on estimations and has to be interpreted with caution, although it might be indicative for the scale of the

Table 3. Costs to the rehabilitation centre of the different rehabilitation protocols for SCI (in Euros)

	According to expert protocol		Calculated staff costs			Allocated overhead costs according to duration of rehabilitation activity			Calculated total costs (staff + overhead)	
Pathology (setting)	**Days (hosp) or sessions amb)**	**Weeks**	**Cost medical staff**	**Cost paramedical staff**	**Total staff costs**	**Hours rehabilitation activities**	**Allocated overhead (€ 15/h)**	**Allocated overhead (€ 25/h)**	**Total cost (overhead € 15/h)**	**Total cost (overhead € 25/h**
SCI										
Paraplegia (hosp)	175	25	3,702	16,166	19,868	497	7,453	12,422	27,321	32,290
Paraplegia (amb)	60	20	740	2,713	3,454	85	1,275	2,125	4,729	5,579
Tetraplegia (hosp)	273	39	5,776	24,911	30,687	775	11,627	19,378	42,313	50,065
Tetraplegia (amb)	78	26	1,203	3,484	4,687	114	1,706	2,844	6,394	7,531

Note: hosp = hospitalization (inpatient); amb = ambulatory (outpatient).

required budget (**Table 5**). As the rehabilitation needs of the vast majority of SCI patients are very complex, taking into account the cost within the convention 7.71 scenario seems justified. The hypothetical budget needed in 2007 would be approximately €5 million, which is in sharp contrast with the estimated costs borne by the centers of around €8 million.

Illustrative cases

As described in the Methods section, 4 patients were selected from a cohort of 68 SCI patients. The centre's total revenues for the hospitalization episode were delivered by the medical administration department (**Table 6**). These patients have been treated within a 7.71 convention (half days as well as full days).

International comparison

Most countries seem to be struggling with the organization of rehabilitation and are searching for a clear rehabilitation concept comprising patients' needs, facilities for the different phases in the trajectory (acute, postacute, and long-term), and continuity of care. Unfortunately, no country has a ready-for-use model for postacute rehabilitation. All countries define different levels (up to 4) of rehabilitation according to the degree of specialization from basic to highly specialized. SCI rehabilitation is assigned to the most specialized level of care, because of the very complex and specific needs and low incidence.

Discussion

The current organization and financing of rehabilitation services in Belgium is heterogeneous and lacks transparency and coherence. The different existing reimbursement systems overlap to a large extent, and referral of patients to the different types of organizations does not take into account their specific needs but instead depends on geographical factors, the physician's decision, or patient's preference. Based on the results of the different parts of the KCE study as described previously, an organizational model for

Table 4. Revenues and NIHDI expenses of standard SCI rehabilitation protocols (in Euros)

		Centre revenues per protocol according to current reimbursement mechanisms			NIHDI expenses per protocol according to current reimbursement mechanisms			Total costs borne by centres applying the protocol
Pathology	**Setting**	**K60**	**9.50 conv**	**7.71 conv**	**K60**	**9.50 conv**	**7.71 conv**	
SCI								
Paraplegia	Hosp	7,459	8,159	16,303	6,714	7,414	16,303	27,321
	Amb	0	2,469	3,360	0	2,378	3,269	4,729
Tetraplegia	Hosp	7,459	11,327	25,466	6,714	10,582	25,466	42,313
	Amb	168	3,377	4,368	168	3,259	4,250	6,394

Note: NIHDI = National Institute for Health and Disability Insurance; hosp = hospitalization (inpatient); amb = ambulatory (outpatient).

Table 5. Total costs, revenues and expenditures for SCI rehabilitation in Belgium (in Euros)

		All centres' revenues/expenditures for the SCI population in Belgium			NIHDI expenses per protocol according to current reimbursement mechanisms			Total costs borne by centres applying the protocol
Pathology	**Setting**	**K60**	**9.50 conv**	**7.71 conv**	**K60**	**9.50 conv**	**7.71 conv**	
SCI								
Paraplegia	Hosp	745,920	815,975	1,630,300	671,400	741,355	1,630,300	2,732,105
	Amb	0	246,900	336,000	0	237,840	326,940	472,857
Tetraplegia	Hosp	745,920	1,132,730	2,546,600	671,400	1,058,210	2,546,600	4,231,330
	Amb	16,750	337,720	436,800	16,750	325,942	425,022	639,355
Total SCI		1,508,590	2,529,325	4,949,700	1,359,550	2,363,347	4,928,862	8,075,647

Note: NIHDI = National Institute for Health and Disability Insurance; conv = convention; hosp = hospitalization (inpatient); amb = ambulatory (outpatient); SCI = spinal cord injury.

Table 6. Revenues during the hospitalization of 4 spinal cord–injured patients in the Rehabilitation Centre UZ Leuven (in Euros)

Patients	Pharmacy	Rehabilitation convention	Technical exams	Hospitalisation	Total revenues per patient
1	2,258	27,561	11,365	100,238	141,422
2	1,031	9,472	5,872	47,828	64,203
3	1,062	8,831	5,924	39,906	55,723
4	759	10,589	3,528	30,856	45,732

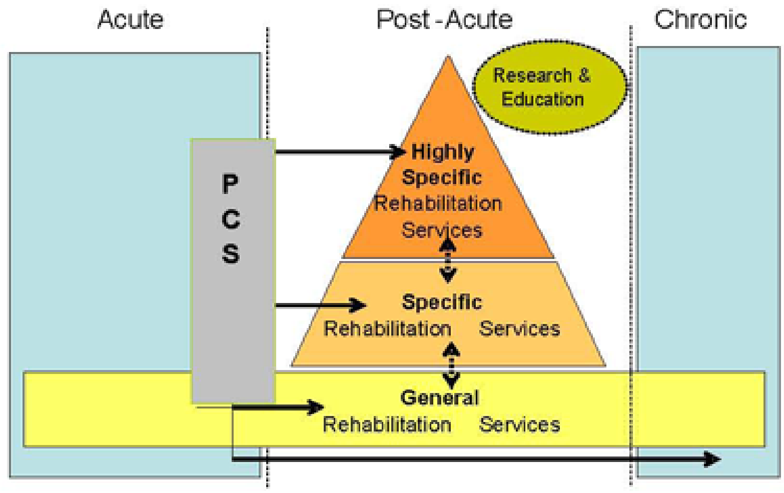

Figure 1. Stratified rehabilitation model, post acute. PCS = patient classification system.

musculoskeletal and neurological rehabilitation has been developed.

Four dimensions are important:

1. The phase of the trajectory of care: acute, postacute, and chronic
2. The setting: inpatient versus ambulatory
3. The idea of a mono- or multidisciplinary approach related to human resources issues
4. The complexity of the rehabilitation needs and goals and thus of the required rehabilitation activities: simple or complex

The proposed conceptual stratified rehabilitation model focuses on the postacute phase as a support tool for organizing rehabilitation.[1] Moreover, it tries to translate and optimize the existing informal organization of MNR in Belgium. **Figure 1** presents the ideas underlying this conceptual model. It is composed of 3 differentiated types of rehabilitation services, taking into account patients' rehabilitation needs and goals: (a) general, (b) specific, and (c) highly specific rehabilitation services. The services of the different rehabilitation levels function in a collaborative way through a clearly structured network. Patients can be referred between the different levels of services depending on the phase of the trajectory. Two criteria are used for separating the levels in this structure: complexity of rehabilitation needs and goals, and incidence and prevalence of consequences of health conditions.

The implementation of this model thus requires a systematic assessment of patients' rehabilitation needs in the acute phase of the disease trajectory by means of a patient classification system (PCS), preferably within the framework of an ICF-based outcome model.[21] The currently available PCS, such as case mix groups in the United States or AN-SNAP in Australia, defines homogeneous groups based on length of stay, but this system is not specific enough to be used as a referral instrument or to define type or intensity of required interventions or necessary professionals.[22,23]

The incidence of SCI is low and the rehabilitation needs and goals of these patients are complex, covering many items of the ICF domains (functions and structures, activities and participation).[21] Referral to a highly specific rehabilitation service therefore seems adequate. Optimally this takes place in a collaborative network with other organizations for the acute and chronic phase or even the ambulatory phase, depending on the accessibility of the services with regard to geographical considerations.

From a financial point of view, different models are possible. In the KCE report, the following was suggested:

- general rehabilitation services: fee for service system (FFS)
- specific rehabilitation services: lump sum or mixed with high weight on lump component

(eg, lump sum for coordination and FFS for therapeutic acts)

- highly specific rehabilitation services: lump sum or envelope or mixed with high weight on lump component.

These proposals have been motivated extensively in chapter 11 of the KCE report.[1]

Even though the incidence of SCI in Europe is relatively low, the financial burden is substantial due to the complex needs of the patients and the long life expectancy in Western countries (high number of YLD).[13] A study published in 2006 confirms "the substantial progress that has occurred over the past 30 years in reducing the mortality rate during the first 2 years after SCI. As a result, life expectancy measured from the time of injury has also increased substantially."[24(p1084)] Specific costs for SCI in Europe are not available in the literature. However the EUROCOST project indicates that, amongst injured patients, the group "vertebral column/spinal cord" ranked high on cost per capita and mean cost. Unfortunately, the percentage of patients with neurological damage in this group is not mentioned. The mean cost for the entire group was €6,600 in The Netherlands and a mean of €3,305 for 10 European countries.[15,16] Among the European countries, there was a great variance concerning incidence as well as costs. Meerding compared the European costs with other continents: "Costs of injuries amounted to 3.7% of total health care budget, which compares favourably with 10% in the US and 8% in Australia."[16(p276)] Also, the cost of an injury per capita in the United States seemed to be 3 times the European estimate.

In the Belgian KCE report, the total estimated cost (for rehabilitation therapy only) is €32,050 for a paraplegic and €48,707 for a tetraplegic patient. These amounts have to be interpreted with caution as they are based on many assumptions concerning the calculated costs, the expert-based rehabilitation protocols, and the used incidence rates. With a hypothetical incidence of 200 new SCIs per year in Belgium, the total expenses of postacute rehabilitation activities as defined previously for the health insurance would be approximately €5 million.

In 4 cases of SCI patients admitted to the Rehabilitation Centre UZ Leuven, the total cost of the acute and postacute (rehabilitation) episode has been calculated, and it varied between €45,732 and €141,422 (comprising also hospitalization, diagnostics, pharmacy, etc). The part of this cost attributed to rehabilitation treatment – €8,831 and €27,561 for the tetraplegic patients and €9,472 and €10,589 for the paraplegic patients – seems lower than the estimated average cost in the KCE report. The largest part of the total cost comprises the hospitalization cost (between €30,856 and €100,238), but technical exams also account for a substantial part of the expenses (between €3,582 and €11,365).

Conclusion

Sustaining an SCI is a devastating event for the patient. In addition, the global burden of disease for society is significant. Even though the incidence is low, the direct costs are estimated to be high due to the relatively low mean age at injury and long life expectancy. In this article, an attempt is made to estimate the direct cost of SCI in the postacute (rehabilitation) phase. An analysis of the organization of SCI rehabilitation in Belgium shows that it is heterogeneous, lacks transparency, and lacks clinical coherence. The current reimbursement system seems insufficient to cover the costs of the rehabilitation centres. Therefore a 3-level stratified rehabilitation model was developed with a general, a specific, and a highly specific level to function in a collaborative network where patient referral is based on the complexity of rehabilitation needs and goals and the incidence/prevalence of the underlying diagnosis. Most SCI patients have such complex needs that referral to the most specific level is indicated. Such a model can only be implemented if an objective patient classification system is available. Further research is urgently needed to develop a system that preferably can be used for clinical purposes (patient referral and determining an adequate rehabilitation program based on the patient's needs and goals) as well as managerial aims (resource allocation in accordance with an adapted rehabilitation pathway).

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Causes and Costs of Unplanned Hospitalizations Among Persons with Spinal Cord Injury

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The purpose of this study was to document causes and average costs of hospitalization among persons with spinal cord injury (SCI). Data were collected prospectively on 430 hospitalizations occurring among 206 persons. Urinary tract complications were the most frequent cause of hospitalization (29.5%), followed by skin conditions (16.5%). Mean charges per hospitalization in 2009 dollars were highest for skin conditions ($75,872) and lowest for endocrine and nutritional problems ($13,530). These data should be useful for life care planning as well as for setting priorities for research and education aimed at preventing unnecessary hospitalizations, reducing costs, and improving quality of life for persons with SCI. **Key words:** *complications, economics, epidemiology, hospitalization, spinal cord injury*

Studies of the National Spinal Cord Injury Statistical Center (NSCISC) database suggest that between 1986 and 1992, 26% of persons with spinal cord injury (SCI) experienced an unplanned hospitalization during the current year due to a secondary medical complication, surgical procedure, or unrelated medical condition.[1] Moreover, among those who were hospitalized, the average number of hospitalizations was 1.5 and the mean length of stay was 11.6 days.[1] Slightly higher hospitalization rates and mean lengths of stay per hospitalization have been reported for veterans with SCI.[2] In population-based samples of persons with SCI residing in Colorado, USA, and Alberta, Canada, the hospitalization rate was 2 to 3 times the expected rate for the general population of comparable age.[3,4] Factors that increase the likelihood of hospitalization include older age, cervical injury level, neurologically complete injury, indwelling urethral catheter, reduced functional capability and independence, lower education level, and availability of private medical insurance.[1-10] With changing health care practices, the advent of health maintenance organizations, and reduced medical complication rates, hospitalization rates and lengths of stay have declined in recent years and as time post injury increases.[2,9-11]

Among all categories of charges, the average annual charges for hospitalizations rank second only to charges associated with attendant care for persons with tetraplegia and rank first among persons with paraplegia.[11,12] Frequent hospitalizations increase the difficulty in obtaining and sustaining employment or becoming involved in other gainful or leisure activities and reduce overall quality of life.

Identifying the causes of unplanned hospitalizations should help guide efforts to reduce their necessity. Since 1973, the NSCISC database has contained information on the number of hospitalizations and the number of days hospitalized that occur each year. Due to the importance of this issue, causes of hospitalization were added to the NSCISC database beginning in October 2000.[9] However, due to limited data collection resources, charges and costs associated with each hospitalization are still not a part of the NSCISC database.

Five American, 2 British, 2 Canadian, 2 Australian, 1 Italian, and 1 French study have

Top Spinal Cord Inj Rehabil 2011;16(4):53–61

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doi: 10.1310/sci1604-53

been conducted to address the question of causes of hospitalization.[4,5,9,10,13-21] In the United States, Davidoff and associates found that during the first postinjury year, the leading causes were additional rehabilitation (19.1%) followed by urinary tract infection (UTI; 17%), deep venous thrombosis (DVT; 12.8%), and removal of spinal instrumentation (12.8%).[5] After the first postinjury year, Meyers and colleagues found the leading causes of hospitalization to be infections (41%), surgical procedures (13%), and physical examinations (11%).[13] Frost and associates found pressure sores were a contributing cause of 44% of hospitalizations.[14] Cardenas and colleagues found genitourinary disorders to be the leading cause of hospitalizations.[9] Most recently, Young et al found pressure sores and other skin conditions to be the leading cause of hospitalization among persons with tetraplegia, followed by orthopedic and urological conditions.[21]

In the United Kingdom, Vaidyanathan and colleagues found that urinary tract disorders accounted for 43% of hospitalizations, followed by cardio-respiratory diseases (23%).[15] Savic and associates also reported urinary tract disorders to be the leading cause of hospitalization in the United Kingdom (41%), but found that skin complications ranked second (17%) followed by digestive system disorders (10%).[16] In Canada, Noreau and colleagues found 54% of hospitalizations were caused by UTI, followed by pressure sores (26%) and pain (15%), whereas Dryden and associates found a plurality of hospitalizations due to respiratory conditions.[4,17] Urinary tract disorders were also the leading cause of hospitalization in Australia.[10,18] In Italy, physiotherapy accounted for 33% and urologic complications 20% of admissions; whereas among persons with tetraplegia in France, urinary complications were the leading cause of hospitalization.[19,20]

The studies from the United Kingdom and Australia also documented average length of stay for each cause of hospitalization. Although the results differed somewhat, skin complications (typically pressure sores) were associated with longer average length of stay than hospitalizations due to other causes.[10,15,16,18]

In addition to documenting average length of stay, one Australian study also attempted to distinguish hospitalizations that were related to SCI from those that were not and those hospitalizations that were potentially preventable from those that were nonpreventable. Of 60 reported hospitalizations, 45 (75%) were deemed to be related to SCI, and only 4 of those were deemed to be potentially preventable.[18]

The purpose of this study was to determine the most frequent causes of hospitalization among persons with SCI in Alabama and the average costs associated with each of those causes. A secondary purpose was to examine predictive factors associated with hospitalization resulting from different causes.

Methods

Study design

The study design was a consecutive case series with a 27-month prospective data collection period. Information was gathered on all unplanned hospitalizations that were able to be identified that occurred between October 1, 1994, and December 31, 1996. Planned hospitalizations for routine annual evaluations or further rehabilitation were excluded from the study.

Study participants

All persons with SCI who were injured between 1973 and 1996 and who were currently being followed at the University of Alabama at Birmingham Spinal Cord Injury Care System (UAB-SCICS) were eligible for the study. There were 1,145 persons who met these criteria.

Case ascertainment

Several procedures were used to identify the occurrence of a hospitalization for inclusion in the study. First, admission sheets that are computer generated whenever a patient enters the UAB-SCICS were scanned each day to identify hospital admissions to any inpatient service among persons with SCI. Second, persons who returned for UAB-SCICS clinic visits and routine annual outpatient evaluations were asked whether they had been hospitalized at another facility since their last UAB-SCICS contact. Third, persons who did not come for their annual evaluation were telephoned to gather routine follow-up data including information on any hospitalizations that had occurred. Fourth, a computer listing of hospitalization claims reports was obtained from the Alabama government agency responsible for processing Medicaid reimbursement requests. Medicaid is a third-party payer for health care services provided to persons who cannot afford the care they receive and have no other health insurance coverage. Finally, a notice was placed in the UAB-SCICS newsletter sent periodically to all its patients. The notice described the study and asked individuals to report any recent hospitalizations that did not occur at the UAB-SCICS to study investigators.

Data collection

When an appropriate hospitalization was identified, the hospital was contacted and both the medical records and billing information associated with that hospital stay were obtained. Data on hospital charges were also obtained from the Medicaid computer listings. Inpatient physician fees are usually billed separately from the hospital charges and are usually difficult and time consuming to acquire, so they were not included in this study.

Data collected from the medical records included age, gender, race, and education level of the patient; neurological level and completeness of injury measured using the current version of the American Spinal Injury Association (ASIA) standards for neurological classification at the time the study was conducted[22]; location of the hospital where admission occurred (urban or rural, UAB-SCICS or elsewhere); length of time the patient had been injured prior to hospitalization; the patient's type of health insurance, length of stay in the hospital, hospital charges, and primary and secondary cause of hospitalization.

Data analysis

Descriptive statistics included means and standard errors of interval level data such as days hospitalized and charges, while frequencies and percentages were used for categorical data. Estimation of hospital costs was based on case-weighted statewide average cost to charge ratios for urban and rural hospitals in the state where the hospitalization occurred.[23] All charge and cost data were adjusted to 2009 dollars using the hospital and related services component of the Consumer Price Index. Mean charges and costs for each cause of hospitalization were compared by one-way analysis of variance (ANOVA).

Results

Overall, 206 persons (18% of all persons potentially eligible for the study) were found to have been hospitalized at least once during the study period. A total of 430 hospitalizations occurred among those 206 persons. This sample size allows estimation of percentages with a 95% confidence interval of ±4.8 percentage points.

Descriptive characteristics of the 430 hospitalizations appear in **Table 1**. Mean age at time of hospitalization was 36.8 years, and 83% of hospitalizations occurred among males, 59.5% occurred among whites, and 56.3% occurred among persons who had less than a high school education. A slight plurality of hospitalizations occurred among persons with paraplegia (54.7%), while 76% occurred among persons with neurologically complete injuries. Most hospitalizations (59.3%) took place more than 5 years after injury and occurred at the UAB-SCICS (61.9%). Most of the remaining hospitalizations occurred in medium-sized cities and rural areas. Medicaid and Medicare were the predominant third-party payers for these hospitalizations.

Urinary tract complications were the leading cause of hospitalization, serving as the primary cause for 29.5% and secondary cause for an additional 8.8% of cases (**Table 2**). Therefore, urinary tract complications contributed to 38.3% of all hospitalizations. Skin complications ranked second as the primary cause of hospitalization, followed by complications of the respiratory, nervous, and digestive systems. Less frequent causes included injuries, psychosocial issues, musculoskeletal and cardiovascular conditions, diseases of the endocrine system, and blood conditions.

Table 1. Study population characteristics of 430 hospitalizations

Characteristic	n	%
Age		
1-29	129	30.0
30-59	280	65.1
≥60	21	4.9
Gender		
Male	357	83.0
Female	73	17.0
Race		
White	256	59.5
African American	174	40.5
Education		
< High school grad	242	56.3
≥ High school grad	188	43.7
Injury level		
Tetraplegia	195	45.3
Paraplegia	235	54.7
ASIA Impairment Scale		
A	327	76.0
B	31	7.2
C	52	12.1
D	20	4.7
Years post injury		
0-5	175	40.7
≥6	255	59.3
Hospital location (county size)		
UAB-SCICS	266	61.9
≥100,000 population	31	7.2
10,000–99,999 population	100	23.2
<10,000 population	33	7.7
Sponsor[a]		
Private insurance	94	21.9
Workers' compensation	30	7.0
Medicaid	275	64.0
Medicare	175	40.7
Other	21	4.9
None (indigent)	4	0.9

Note: UAB-SCICS = University of Alabama Birmingham Spinal Cord Injury Care System.

[a]Percentages add to more than 100 because some patients had more than one sponsor of care.

The urinary tract complications were almost always infections. Pyelonephritis, a sign of a more severe upper UTI, was specifically cited in 24 instances; the remaining 120 infections were less specific. Urinary tract stones occurred in 10 instances, orchitis/epididymitis in 7 instances, and other urinary tract complications in 4 instances. Of 119 skin complications, 114 were pressure sores (95.8%), and the remaining 5 were cases of abscess and/or cellulitis. Unlike urinary tract and skin conditions, respiratory complications were more varied, with pneumonia ranking first (19 cases; 28.8%). Nervous system complications were mostly cases of autonomic dysreflexia (56 cases; 82.4%); however, there were 5 cases each of syringomyelia and severe spasticity and 2 seizure disorders. Psychosocial complications resulting in hospitalization included 22 cases of substance abuse (73.3%), 6 cases of severe depression (20.0%), and 2 other conditions.

Urinary tract complications were the leading cause of hospitalization for all age groups, genders, races, and education and injury levels. Among persons with tetraplegia, respiratory complications ranked second, whereas skin conditions ranked second among persons with paraplegia. Urinary tract complications ranked first among all ASIA Impairment Scale (AIS) grades except AIS D. Musculoskeletal conditions ranked first for persons with AIS D injuries. Urinary tract complications also ranked first during all postinjury years, followed by respiratory conditions during the first 5 postinjury years and skin conditions during postinjury years 6 and beyond.

As seen in **Table 3**, primary cause of hospitalization differed significantly by hospital location ($P < .0001$). Although urinary tract complications ranked first at all locations, they accounted for only 25.6% of hospitalizations at the UAB-SCICS but 42.4% of hospitalizations at rural hospitals. Respiratory complications accounted for 30.3% of admissions at rural hospitals but less than 10% at the UAB-SCICS and other urban hospitals. Skin conditions were frequent causes of hospitalization at the UAB-SCICS, but not at rural hospitals. Virtually all hospitalizations caused by nervous system disorders occurred at the UAB-SCICS.

Mean length of stay per hospitalization by primary cause of hospitalization appears in **Table 4**. Overall, mean length of stay was 10.0 days. Differences in mean length of stay by primary cause of hospitalization were statistically significant ($P < .0001$). Skin conditions had the longest mean length of stay at 19.8 days, followed by musculoskeletal system disorders at 14.0 days

Table 2. Primary and secondary causes of hospitalization

	Primary		Secondary		Total	
Cause	n	%[a]	n	%[a]	n	%[a]
Urinary tract	127	29.5	38	8.8	165	38.3
Skin	71	16.5	48	11.2	119	27.7
Respiratory system	54	12.6	12	2.8	66	15.4
Nervous system	36	8.4	32	7.4	68	15.8
Digestive system	35	8.1	20	4.7	55	12.8
Injury	27	6.3	0	0.0	27	6.3
Psychosocial problem	20	4.7	10	2.3	30	7.0
Musculoskeletal system	19	4.4	6	1.4	25	5.8
Cardiac system	15	3.5	4	0.9	19	4.4
Endocrine system	9	2.1	16	3.7	25	5.8
Other	16	3.7	1	0.2	17	3.9
Unknown	1	0.2	0	0.0	1	0.2
Total	430	100.0	187	43.5	617	----

[a]All percentages based on n = 430 hospitalizations.

Table 3. Primary cause of hospitalization by hospital location

			County population					
	UAB-SCICS		>100,000		10,000 - 99,999		<10,000	
Cause	n	%	n	%	n	%	n	%
Urinary tract	68	25.6	10	32.2	35	35.0	14	42.4
Skin	57	21.4	4	12.9	10	10.0	0	0.0
Respiratory system	23	8.7	2	6.5	19	19.0	10	30.3
Nervous system	35	13.2	0	0.0	1	1.0	0	0.0
Digestive system	19	7.1	2	6.5	12	12.0	2	6.1
Injury	15	5.6	2	6.5	9	9.0	1	3.0
Psychosocial problem	8	3.0	5	16.1	4	4.0	3	9.1
Other	41	15.4	6	19.3	10	10.0	3	9.1

Note: UAB-SCICS = University of Alabama Birmingham Spinal Cord Injury Care System.

and digestive system diseases at 10.9 days. Diseases of the endocrine system had the shortest mean length of stay at 5.4 days.

Differences in mean charges and costs for each cause of hospitalization adjusted to 2009 dollars were also statistically significant ($P < .0001$). Overall, mean charges per hospitalization were $40,023 and mean cost per hospitalization was $20,583 (**Table 5**). Mean charges per hospitalization ranged from $75,872 for skin conditions and $69,465 for musculoskeletal conditions to only $13,530 for endocrine system diseases. Mean cost per hospitalization was highest for skin conditions ($38,866) and was lowest for endocrine system diseases ($7,063).

Mean charges per day were highest for nervous system disorders ($6,578), followed by cardiac diseases ($6,217) and musculoskeletal conditions ($4,962). Mean charges per day were lowest for psychosocial problems ($1,840), endocrine system diseases ($2,506), and urinary tract conditions ($3,289).

Table 4. Mean length of stay per hospitalization by primary cause of hospitalization

	Days hospitalized		
Primary cause	**n**	**Mean**	***SE***
Urinary tract	127	7.3	0.6
Skin	71	19.8	1.9
Respiratory system	54	7.5	0.8
Nervous system	36	6.9	1.0
Digestive system	35	10.9	4.2
Injury	27	8.2	1.8
Psychosocial problem	20	9.0	1.3
Musculoskeletal system	19	14.0	3.5
Cardiac system	15	7.4	1.9
Endocrine system	95.4	1.5	–
Other	16	8.0	1.9
Unknown	15.0	0.0	–
Total	430	10.0	0.6

Note: UAB-SCICS = University of Alabama Birmingham Spinal Cord Injury Care System.

Discussion

The descriptive characteristics associated with the hospitalizations in this study are consistent with those of the UAB-SCICS population of persons with SCI who were alive at the time of the study with 2 exceptions. Several studies have shown that hospitalizations are more common among persons with AIS A injuries.[1,10,20] Therefore, it is not surprising that 76% of all hospitalizations in this study were associated with AIS A injuries. However, it is also interesting to note that education levels below high school graduate are overrepresented in this study compared to the UAB-SCICS population.[24] Lower education levels are likely associated with lower income levels, Medicaid sponsorship, more restricted access to preventive health care, less ability to care for oneself, and hence greater risk of secondary medical complications and hospitalization.

Like most previous studies, this one revealed UTIs to be the leading cause of hospitalization, particularly in small town and rural hospitals. Although the characteristics of the infections that led to these hospitalizations are unknown, most UTIs are asymptomatic and might be better left untreated, unless significant symptoms occur, to avoid repeated infections with more pathogenic organisms that eventually become multidrug resistant.[25-27] These data suggest a need for better education of rural physicians who are not as experienced in caring for persons with SCI and may be treating some UTIs unnecessarily.

Virtually all hospitalizations for which the primary cause was autonomic dysreflexia occurred at the UAB-SCICS. Since autonomic dysreflexia is sometimes unrecognized by less experienced physicians, it is possible if not likely that some

Table 5. Mean charges and costs per hospitalization adjusted to 2009 dollars by primary cause of hospitalization

		Charges ($)		Costs ($)	
Primary cause	**n**	**Mean**	***SE***	**Mean**	***SE***
Urinary tract	124	24,007	2,171	12,617	1,123
Skin	68	75,872	8,835	38,866	4,524
Respiratory system	49	29,975	3,515	15,096	1,811
Nervous system	34	45,386	6,196	23,213	3,170
Digestive system	34	45,062	16,971	23,157	8,689
Injury	26	27,788	3,897	14,308	2,008
Psychosocial problem	20	16,560	2,315	8,505	1,183
Musculoskeletal system	19	69,465	14,056	35,579	7,200
Cardiac system	15	46,006	13,912	23,562	7,125
Endocrine system	9	13,530	3,092	7,063	1,549
Other	16	46,344	11,854	23,871	6,072
Unknown	1	2,707	0	1,386	0
Total[a]	415	40,023	2,580	20,583	1,321

[a]Fifteen cases had unknown charges and costs.

cases of autonomic dysreflexia were misclassified as other causes of admission at other hospitals. The UAB-SCICS has developed autonomic dysreflexia posters and distributed them to emergency rooms throughout Alabama, but additional training of emergency room physicians might be helpful.

Hospitalizations due to substance abuse and depression should also be potentially preventable with appropriate psychosocial interventions. These psychosocial problems contributed to 7% of all hospitalizations. Medicaid was the primary sponsor of care for 81.3% of admissions due to psychosocial problems compared to 62.7% for other causes of hospitalization ($P < .0001$). Moreover, among 25 total persons with psychosocial admissions, there were 87 total hospitalizations (3.5 admissions per person) compared with only 1.9 admissions per person for those who did not have a psychosocial hospitalization ($P < .0001$). Therefore, preventing depression, substance abuse, and other psychosocial problems should lead to fewer hospitalizations for other causes as well.

Pressure sores, UTIs, and autonomic dysreflexia were common secondary diagnoses at the time of hospitalization. This is consistent with the high prevalence of these secondary complications in the general SCI population.[25,28] Conversely, when injuries occur, they are always the primary cause of hospitalization.

It is not surprising that pressure sores and musculoskeletal conditions were associated with the highest charges and costs, because these admissions often involve surgery. Young et al also found pressure sores and musculoskeletal conditions to be the most costly causes of hospitalization.[21] Conversely, charges and costs are low for psychosocial problems, diabetes, and UTIs that do not usually require surgical management. Most pressure sores that become severe enough to require hospitalization and surgical repair should be preventable with better patient and family education, an appropriate home environment, and adequate family resources.

This study has several limitations. First, the data were collected between 1994 and 1996, and clinical practices have changed since then. Some conditions that were routinely treated in the hospital are now treated on an outpatient basis. With the advent of managed care, inpatient lengths of stay are generally shorter today than they were 15 years ago.[1,9] Moreover, inpatient charges per day for persons with SCI have risen faster than the rate of inflation, in part due to the development of new treatments and technologies.[29] As a result, even after adjustment to 2009 dollars, charges and costs may be underestimated despite shorter lengths of stay.

Second, hospitalizations in Alabama and surrounding states may not be representative of those in the rest of the United States. Access to care is an issue among poorer segments of the Alabama population, particularly in rural areas. Mean lengths of stay are typically shorter in Alabama for persons with Medicaid sponsorship,[7] and 64% of hospitalizations in this study had Medicaid sponsorship. In general, hospital charges and costs in Alabama should be below the national average. In fact, based on separate analyses of the NSCISC database,[30,31] among SCI Model System hospitals in the United States, the UAB-SCICS has the lowest lengths of stay and charges for inpatient acute care and rehabilitation immediately following the injury.

Finally, the study was not population-based. Therefore, actual hospitalization rates and risk factors for hospitalizations due to particular causes could not be calculated. Despite multiple case ascertainment methods, some hospitalizations that occurred outside the UAB-SCICS and were sponsored by payers other than Medicaid were likely missed. The 18% of eligible persons who were identified to have been hospitalized during this study period is below the 26% annual hospitalization rate reported elsewhere.[1] However, the rate of multiple hospitalizations among those hospitalized at least once is consistent with previous studies.[1] Causes of hospitalization that are more common at the UAB-SCICS or with Medicaid sponsorship will be proportionately overrepresented in this study. Also, there were 15 hospitalizations (3.5%) with missing charges that could slightly bias results.

Conclusions

UTIs are the leading cause of hospitalization among persons with SCI, followed by pressure sores and respiratory conditions. Pressure sores are the most expensive cause of hospitalization. Psychosocial diagnoses are associated with 7% of all hospitalizations and are the primary cause of 4.7%. Most hospitalizations appear to be preventable, particularly those related to pressure sores, UTIs, and psychosocial problems. Finally, prevention of hospitalizations would result in considerable savings of public funds (Medicare and Medicaid) and improved quality of life for persons with SCI. This study has provided useful information for life care planning and has identified the causes of hospitalization that would need to be targeted in any prevention efforts.

Acknowledgments

This work was supported in part by grant H133N50009-96A from the National Institute on Disability and Rehabilitation Research (NIDRR), US Department of Education, Washington, DC.

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Cost of Treating Pressure Ulcers for Veterans with Spinal Cord Injury

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Veterans comprise almost 17% of the 250,000 persons with spinal cord injury/disorder (SCI/D) in the United States. Pressure ulcers are common complications of SCI/D. We compared annual health care utilization and costs between veterans with and without pressure ulcers in the Veterans Health Administration (VHA). Veterans with pressure ulcers had more total inpatient days on average (61.00 vs 9.19; $P < .001$) and higher total health care costs ($100,935 vs $27,914; $P < .001$) due primarily to higher inpatient costs ($91,341 vs $13,754; $P < .05$). Our results highlight the need to identify patients at risk for pressure ulcers who could benefit from targeted skin care management interventions. **Key words:** *health care cost, hospitalization, pressure ulcer, spinal cord injury/disorder, veteran*

There are approximately 250,000 persons with spinal cord injury/disorder (SCI/D) in the United States and an estimated 11,000 new injuries per year.[1] Pressure ulcers are common, serious complications of SCI/D[2,3] with annual incidence rates ranging from 20% to 31% and prevalence rates ranging from 10% to 30% in patients with SCI.[3,4] Pressure ulcers may disrupt rehabilitation and adversely affect overall quality of life,[3,5-8] frequently resulting in hospitalization.[2] If a pressure ulcer is severe (eg, stage III/IV), it can result in further disability, decreased mobility, loss of independence, the need for surgical interventions, and potentially fatal infections.[3,6,9] It has been estimated that the cost of care for pressure ulcers is about $1.2 to $1.3 billion annually for patients with SCI/D in the United States.[3]

Veterans make up almost 17% of the SCI population,[10] and SCI/D is the most costly medical condition for veterans ($34,551 per person annually in 2008 dollars).[11] Interdisciplinary teams at 24 Regional SCI/D Centers located in Department of Veterans Affairs (VA) medical centers deliver primary care, acute rehabilitation, disability management, ongoing rehabilitation, and long-term care for veterans with SCI/D. To inform the work of clinicians at these centers and the decision making of policymakers regarding the burden of illness that pressure ulcers pose for the health care system, the objective of this study was to compare the annual health care utilization and costs of veterans with and without pressure ulcers in the Veterans Health Administration (VHA).

Methods

Study design

We conducted a retrospective analysis of veterans diagnosed with SCI/D who received care at a VA health care facility. To examine health care utilization and costs associated with incident pressure ulcers, we first determined which patients

Top Spinal Cord Inj Rehabil 2011;16(4):62–73

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doi: 10.1310/sci1604-62

had a pressure ulcer diagnosis in fiscal year (FY) 2007 (ie, October 1, 2006, through September 30, 2007) but no pressure ulcer diagnosis in FY 2006. We then described those patients' health care utilization and costs during the 12-month period following the date of their first pressure ulcer diagnosis in FY 2007 (ie, their "index date" for this study). We included all patients who were diagnosed with a pressure ulcer in FY 2007 regardless of whether they were diagnosed and treated in inpatient or outpatient settings. Patients without pressure ulcers in FY 2007 who developed a pressure ulcer in FY 2008 were excluded from this study. For patients without pressure ulcers in FY 2006 through FY 2008, we examined health care utilization and costs during FY 2008. For these patients, their index date was the beginning of FY 2008 (October 1, 2007). We restricted our analyses to veterans in our cohort who were alive at the index date.

Data sources

Data for this study came from national VA data sources. We used the cohort of veterans with SCI/D created by the VA Allocation Resource Center (ARC), which maintains an ongoing registry of veterans with SCI/D that is used to allocate resources to VA medical centers. Health care utilization was obtained from the Medical SAS Inpatient and Outpatient Datasets extracted from the National Patient Care Database, which captures inpatient and outpatient utilization from the electronic record system of local VA medical centers,[12,13] and from VA Fee Basis files,[14] which capture claims for non-VA services paid for by the VA. Health care costs were obtained from the VA Decision Support System (DSS) National Data Extracts (NDE), which contain cost estimates of VA care derived from an activity-based cost allocation system.[15] Pharmacy data were obtained from the DSS Pharmacy NDEs, which capture medications dispensed from the electronic record systems of VA medical centers.[16]

Patients

To be included in our study cohort, veterans must have had an inpatient *International Classification of Diseases, 9th Revision* (*ICD-9*) code listed below and additional utilization of either an SCI/D outpatient center or hospitalization in an SCI/D center bed section. The codes include: 806.0-806.9 (fracture of vertebral column with SCI), 907.2-907.3 (late effects of SCI), 952.00-952.9 (SCI without evidence of spinal bone injury), 953.0-953.9 (injury to nerve root and spinal plexus), and 344.xx (paraplegia and quadriplegia not otherwise specified [NOS]).

We identified pressure ulcers based on the *ICD-9* diagnostic codes in the Medical SAS Inpatient or Outpatient Datasets or in the VA Fee Basis Files (ie, 707.0x). The result was the formation of 2 patient groups for this study: patients with incident pressure ulcers during FY 2007 and patients without pressure ulcers during FY 2007.

Health care utilization and costs

Outpatient utilization was categorized as primary care, mental health care, specialty care, and other outpatient care (such as ancillary care, home care, etc) based on clinic codes in the VA Medical SAS Outpatient Datasets. We examined the number of outpatient encounters that veterans had for each of these categories of care. Because veterans may visit more than one clinic while they are at a VA facility, they may have had more than one encounter per facility visit. Outpatient pharmacy use was categorized as chronic medications, defined as those for which a patient received more than one 30-day supply, and acute medications, defined as those medications for which a patient received no more than one 30-day supply. Inpatient utilization included the total number of hospital days for short-term medical/surgical, SCI, psychiatric, rehabilitation, and long-term care, based on time spent in that care unit (ie, VA bed section), and days of non-VA care financed by VA from the VA Fee Basis databases.

We examined the direct costs of patient care from the VA's (ie, the payer/provider's) perspective; our cost estimates reflect VA's expenditures for care of these patients. Costs for outpatient care, outpatient pharmacy, and inpatient care were obtained from VA DSS NDEs.[15] The DSS extracts information from the VA's accounting and payroll system and combines it with workload information from patient care and administrative departments to produce cost estimates.[15] These databases contain estimates of personnel costs, including physicians, nurses, technicians, and other staff, as well as costs of supplies and other administrative/overhead expenses of inpatient stays and outpatient encounters. Pharmacy costs in DSS NDEs include the purchase price of the medication as well as dispensing and administrative/overhead costs.[16] Costs of non-VA hospitalizations financed by VA were obtained from the VA Fee Basis databases.[14] We examined annual total costs per patient, which consisted of total outpatient (primary care, specialty care, mental health care, and other costs), total outpatient pharmacy (chronic and acute medication costs), and total inpatient costs. All costs were adjusted to 2008 dollars using the Consumer Price Index.

Patient characteristics

Health care utilization and costs were adjusted for patient demographic, clinical, and other factors in multivariable models described below. Demographic characteristics of patients including age, race, ethnicity, and marital status were obtained from the VA Medical SAS Inpatient and Outpatient Datasets.[12,13] Comorbid conditions were determined from diagnoses in VA databases during the 12-month period prior to the index date. History of depression was based on diagnosis codes from FY 1999 to FY 2008.

Injury characteristics of veterans including level (tetraplegia, paraplegia) and duration of injury (0-10, 10-20, >20 years) were obtained from the VA Spinal Cord Dysfunction (SCD) Registry. SCI/D etiology was classified as traumatic (eg, vehicular, fall, act of violence, sports injury or other-traumatic), non-traumatic (eg, arthritic disease of the spine, poliomyelitis, tumor, infection or abscess, and other-disease), or both traumatic and nontraumatic based on SCD Registry information supplemented with *ICD-9* codes in the Medical SAS datasets if registry data were missing.

We used the residential zip code of each veteran to obtain associated geographic data including the average household income in each patient's zip code from the 2000 US census.[17] Travel time in minutes between zip code of residence and the nearest VA facility was calculated using geographic information system software (Network Analyst) that is available from the Environmental Science Research Institute in Redlands, California (ArcGIS 9.3). Utilization and cost information during the 12-month period prior to the index date were gathered from national VA databases.

Analysis

Bivariate and multivariable analyses were conducted using SAS version 9.1 (SAS Institute, Cary, North Carolina) and STATA SE version 11.0 (StataCorp LP, College Station, Texas). For bivariate analyses, characteristics prior to the index date were compared between patients with or without pressure ulcers using *t* tests or chi-square tests.

Differences in the health care utilization and costs between patients with or without pressure ulcers during the 12-month period following the index date were analyzed using bootstrapping approaches to account for the non-normal distribution of utilization and cost data. We used bias-corrected accelerated nonparametric bootstrapping procedures to estimate 95% confidence intervals (95% CIs).[18] We investigated statistical significance of the differences in means by examining whether the 95% CIs included 0. To conduct the bootstrap analyses, a series of 1,000 random samples were drawn, with replacement, from the data, and then the difference in means was recomputed after each resampling. The difference in means from these 1,000 resamplings were sorted and then used to estimate upper and lower bounds of the 95% CI.

To investigate the association of pressure ulcers with total hospital days and total costs, we used multivariable regression analyses, controlling for veteran's demographic, clinical, and other factors described previously. Because the number of hospital days in the 12-month period after the index date were non-negative integers, we used zero-inflated negative binomial (ZINB) count models for our multivariable analysis. The ZINB model is a count data model that allows for overdispersion where the conditional variance exceeds the conditional mean, and it adjusts for the portion of patients who would have no hospitalization regardless of the values of the independent variables. Model specification tests indicated that the ZINB model was the most appropriate count model.[19,20] To examine the association between pressure ulcers and total direct health care costs after controlling for other factors, we used generalized linear models (GLM).[21] The GLM used includes a distribution function that describes the expected distribution of the costs and a link function that describes the scale on which the variables in the model are related to costs.[22] We used gamma distribution with a log link based on results from a modified Park test and a Box-Cox test.[23-25]

Results

Patients

Of the 10,977 patients who met our inclusion criteria, 11% had an incident pressure ulcer in FY 2007 (**Table 1**). Patients with incident pressure ulcers were more likely to have had a traumatic injury, an injury for >20 years, a hospitalization in the prior year, more outpatient visits in the prior year, and diabetes (**Table 1**).

Health care utilization

Patients with pressure ulcers had significantly more health care utilization during the 12-month period following the index date than patients without pressure ulcers. After controlling for factors in the multivariable ZINB model, patients with pressure ulcers averaged nearly 52 more total inpatient days (61.00 vs 9.19) than patients without pressure ulcers (P <.001) (**Tables 2** and **4**). The greater number of hospital days for patients with pressure ulcers was due primarily to more days in SCI care units (nearly 36 more days) and in long-term care (nearly 11 more days) (P < .05). Patients with incident pressure ulcers also had more outpatient encounters than patients without pressure ulcers during this time period (**Table 2**). Patients with pressure ulcers had nearly 8 more outpatient encounters with specialists (18.94 vs 11.39; P <.05) and nearly 13 more encounters for other outpatient services (52.34 vs 39.80; P <.05) than those without pressure ulcers.

Other factors associated with fewer total inpatient days from the ZINB model included having paraplegia rather than tetraplegia (5 fewer days), having an injury longer than 10 years (>3 fewer days), having more outpatient visits during the 12-month period prior to the index date (0.07 fewer days as outpatient encounters increased), and having a longer travel time to the nearest VA facility (0.06 fewer days as minutes to a VA facility increased) (P <.001). Factors associated with more total inpatient days included older age (0.34 more days as age increased), hospitalization in the 12-month period before the index date (18 more days), and a history of depression (nearly 5 more days) (P <.001) (**Table 4**).

Health care costs

Health care costs for those with pressure ulcers were higher during the 12-month period following the index date than for those without pressure ulcers. After adjusting for covariates in GLM analyses, total health care costs were $73,021 higher for patients with an incident pressure ulcer ($100,935 vs $27,914; P <0.001) (**Tables 3** and **4**; **Figure 1**). These higher total costs were due primarily to higher total inpatient costs for patients with pressure ulcers ($91,341 vs $13,754; P <.05). The largest category of inpatient costs was for care received in an SCI unit. This care was over 10 times higher ($51,901) for patients with versus without pressure ulcers ($56,895 vs $4,994; P <.05). Moreover, total outpatient costs during the 12-month period after the index date were also $8,559 higher for patients with pressure ulcers ($19,844 vs $11,829; P <.05), with the largest expenditure for care from a specialist. Total outpatient pharmacy costs were also $781 higher for patients with pressure ulcers ($2,394 vs 1,613; P <.05).

Other factors associated with lower total costs from the GLM analysis included being married ($4,248 lower), having paraplegia rather than tetraplegia ($10,166 lower), and having greater travel time to nearest VA ($142 lower as minutes to a VA facility increased) (P <.05). Factors associated with higher total health care costs included hospitalization in the 12-month period before the index date ($21,901 higher), more

Table 1. Characteristics of veterans with and without pressure ulcers

Characteristics	With pressure ulcers (n=1,220)	Without pressure ulcers (n=9,757)	*P*
Race			
Black	267 (21.9%)	1,912 (19.6%)	.059
White	926 (75.9%)	7,621 (78.1%)	.080
Other	27 (2.2%)	224 (2.3%)	.855
Hispanic	69 (5.7%)	577 (5.6%)	.940
Gender			
Male	1,195 (98.0%)	9,465 (97.1%)	.064
Female	25 (2.1%)	292 (2.9%)	
Marital status			
Married	523 (42.9%)	4,334 (44.4%)	.304
Age, years	59.4 (13.6)	59.4 (13.5)	.893
Level of SCI/D injury			
Tetraplegia	478 (39.2)	3,845 (39.4%)	<.0001
Paraplegia	735 (60.2%)	5,109 (52.4%)	
Unknown	7 (0.6%)	803 (8.2%)	
SCI/D etiology			
Traumatic	865 (70.9%)	5,497 (56.3%)	<.0001
Nontraumatic	201 (16.5%)	2,309 (23.7%)	
Both[a]	45 (3.7%)	669 (6.9%)	
Unknown	109 (8.9%)	1,282 (13.1%)	
Duration of injury			
0-10 yrs	349 (28.6%)	2,293 (23.5%)	<.0001
10-20 yrs	198 (16.2%)	1,614 (16.6%)	
>20 yrs	455 (37.3%)	2,569 (26.3%)	
Unknown	218 (17.9%)	3,281 (33.6%)	
Travel time to nearest VA, minutes	52.2 (45.8)	59.4 (50.7)	<.0001
Hospitalized in prior year	832 (68.2%)	3,185 (32.6%)	<.0001
No. of outpatient visits in prior year	44.9 (37.4)	43.6 (33.5)	.253
Average household income in zip code, $	51,491.4 (19072.4)	50,295.3 (17512.6)	.037
COPD	98 (8.0%)	808 (8.3%)	.766
History of depression	528 (43.3%)	4,165 (42.7%)	.694
Diabetes	253 (20.7%)	1,496 (15.3%)	<.0001

Note: Values are shown as n (%) or mean (*SD*). SCI/D = spinal cord injury/disorder; VA = Veterans Affairs; COPD = chronic obstructive pulmonary disorder.

[a]Both traumatic and non-traumatic diagnoses were present.

outpatient visits in the year prior to the index date ($97 higher as outpatient encounters increased), and comorbidities (>$5,000 higher) ($P < .05$) (**Table 4**).

Discussion

In a large cohort of veterans with SCI/D, incident pressure ulcers were associated with higher total health care costs and hospitalizations over a 12-month period for patients with pressure ulcers than patients without them. After adjusting for patient demographic, clinical, and other characteristics, total annual health care costs per patient were $73,021 higher for patients with pressure ulcers ($100,935 vs $27,914) and annual hospitalizations were nearly 52 days longer (61.00 vs 9.19 days).

This study highlights the burden of illness of SCI/D for both patients and the health care system and demonstrates the larger additional burden of illness if these patients develop a pressure ulcer. Prior studies have examined the costs of veterans with SCI/D[11,26,27]; however, less is known about the impact of pressure ulcers on veterans with SCI/D. In a previous study of veterans with SCI/D, average inpatient and outpatient costs for a sample of 675 patients were $23,647 in 2008 dollars.[26] Because

Table 2. Health care utilization among veterans with and without pressure ulcers

	With pressure ulcers (n=1,220)	Without pressure ulcers (n=9,757)	
	Mean **Median (IQR)**	**Mean** **Median (IQR)**	**Difference (95% CI)[a]**
Outpatient care, no. of encounters			
Primary care	4.08 2 (0-5)	3.41 2 (0-4)	0.67 (0.28 to 1.07)
Mental health	1.85 0 (0-1)	2.23 0 (0-1)	-0.38 (-0.92 to 0.43)
Specialty care	18.94 14 (6-25)	11.39 8 (2-16)	7.56 (6.43 to 8.76)
Other outpatient	52.34 46 (21-73.5)	39.80 34 (15-57)	12.54 (10.16 to 15.16)
Outpatient pharmacy[b]			
Chronic medications	68.56 54 (17-106)	69.52 55 (16-103)	-0.96 (-4.62 to 2.62)
Acute medications	2.78 1 (0-4)	2.25 1 (0-3)	0.53 (0.30 to 0.85)
Inpatient care, no. of days			
Medical/surgical	5.53 0 (0-5)	1.03 0 (0-0)	4.50 (3.78 to 5.64)
Rehabilitation	0.51 0 (0-0)	0.07 0 (0-0)	0.43 (0.14 to 0.92)
SCI	39.16 0 (0-43)	3.28 0 (0-0)	35.88 (31.93 to 39.98)
Mental health	0.17 0 (0-0)	0.44 0 (0-0)	-0.27 (-0.44 to 0.02)
ICU	1.88 0 (0-0)	0.22 0 (0-0)	1.66 (1.24 to 2.50)
Long-term care	15.83 0 (0-0)	5.24 0 (0-0)	10.59 (7.61 to 14.23)
Other care	0.45 0 (0-0)	0.27 0 (0-0)	0.18 (-0.06 to 0.44)
Total VA hospital days	55.81 15 (0-75)	5.39 0 (0-1)	50.42 (45.88 to 55.74)
Non-VA hospital	5.02 0 (0-0)	2.87 0 (0-0)	2.15 (0.80 to 4.54)
Total hospital days[c]	61.00 17 (0-82)	9.19 0 (0-1)	51.80 (44.12 to 59.49)

Note: IQR = interquartile range; SCI = spinal cord injury; ICU = intensive care unit; VA = Veterans Affairs.

[a]CI for the difference in utilization for patients with pressure ulcers minus utilization for patients without pressure ulcers.

[b]Outpatient medications are the number of 30-day supplies for medications that patients received during the 12-month period after the index date. Chronic medications were defined as those for which a patient received more than one 30-day supply. Acute medications were defined as those medications for which a patient received no more than one 30-day supply.

[c]Mean total hospital days were adjusted with zero-inflated negative binomial models including covariates in Table 4.

Table 3. Health care costs among veterans with and without pressure ulcers

	With pressure ulcers (n=1,220)	Without pressure ulcers (n=9,757)	
	Mean Median (IQR)	**Mean Median (IQR)**	**Difference (95% CI)[a]**
Outpatient care, $			
Primary care	1,149 367 (0-1,190)	914 361 (0-1,005)	235 (108 to 394)
Mental health	298 0 (0-7)	424 0 (0-40)	-126 (-205 to 7)
Specialty care	9,343 5,353 (1,746-11,327)	5,176 2,669 (534-6,634)	4,167(3,310 to 5,029)
Other outpatient	9,055 5,043 (2,180-10,811)	5,316 2,780 (1,044-5,965)	3,739 (3,049 to 4,760)
Total outpatient	19,844 13,170 (6,143-25,928)	11,829 7,553 (2,996-15,366)	8,015 (6,683 to 9,415)
Outpatient medications,[b] $			
Chronic medications	2,230 880 (244-2,076)	1,503 708 (171-1,767)	727 (390 to 1,678)
Acute medications	164 23 (0-90)	109 1 (0-56)	54 (10 to 125)
Total pharmacy	2,394 949 (280-2,256)	1,613 762 (195, 1,871)	781 (406 to 1,656)
Inpatient care, $			
Medical/surgical	10,479 0 (0-9,821)	2,072 0 (0-0)	8,407 (7,208 to 10,265)
Rehabilitation	929 0 (0-0)	149 0 (0-0)	781 (235 to 1,862)
SCI	56,895 0 (0-62,018)	4,994 0 (0-0)	51,901 (45,600 to 58,407)
Mental health	245 0 (0-0)	442 0 (0-0)	-197 (-407 to 488)
ICU	7,836 0 (0-0)	1,046 0 (0-0)	6,789 (4,867 to 10,073)
Long-term care	11,334 0 (0-0)	3,791 0 (0-0)	7,543 (5,522 to 10,047)
Other care	1,065 54 (0-727)	325 0 (0-0)	741 (523 to 1,177)
Non-VA	2,557 0 (0-0)	935 0 (0-0)	1,622 (1,069 to 2,428)
Total inpatient	91,341 29,788 (0-121,841)	13,754 0 (0-4,278)	77,587 (69,009 to 85,355)
Total costs,[c] $	100,935 57,623 (21,714-155,810)	27,195 11,579 (4,467-26,525)	73,021 (64,236 to 81,806)

Note: IQR = interquartile range; SCI = spinal cord injury; ICU = intensive care unit; VA = Veterans Affairs.

[a]CI for the difference in utilization for patients with pressure ulcers minus utilization for patients without pressure ulcers.

[b]Outpatient medications are the number of 30-day supplies for medications that patients received during the 12-month period after the index date. Chronic medications were defined as those for which a patient received more than one 30-day supply. Acute medications were defined as those medications for which a patient received no more than one 30-day supply.

[c]Mean total hospital days were adjusted with zero-inflated negative binomial models including covariates in Table 4.

Table 4. Factors associated with total inpatient days and total health care costs per year in patients with and without pressure ulcers

	Change in inpatient days (95% CI)	*P*	Change in total healthcare costs ($) (95% CI)	*P*
Pressure ulcer status	51.80 (44.12 to 59.49)	<.001	73,021 (64,236 to 81,806)	<.001
Race				
Non-Black[a]				
Black	1.51 (-0.85 to 3.88)	.21	2,512 (-1,437 to 6,460)	.212
Ethnicity				
Non-Hispanic[a]				
Hispanic	2.78 (-1.32 to 6.87)	.184	6,183 (-368 to 12,734)	.064
Gender				
Female[a]				
Male	-6.02 (-13.11 to 1.08)	.097	-5,670 (-16,642 to 5,302)	.311
Marital status				
Not married[a]				
Married	-2.86 (-4.62 to -1.09)	.002	-4,248 (-7,051 to -1,445)	.003
Age, years	0.34 (0.27 to 0.42)	<.001	275 (143 to 408)	<.001
Level of SCI/D injury				
Tetraplegia[a]				
Paraplegia	-5.45 (-7.48 to -3.41)	<.001	-10,166 (-13,479 to -6,853)	<.001
Unknown	-9.09 (-12.46 to -5.71)	<.001	-22,583 (-26,662 to -18,505)	<.001
SCI/D etiology				
Traumatic[a]				
Non-traumatic	1.40 (-0.97 to 3.76)	.247	2,061 (-1,741 to 5,863)	.288
Both[b]	0.97 (-2.52 to 4.46)	.586	2,036 (-4,437 to 8,509)	.538
Unknown	7.50 (-2.53 to 12.48)	.003	2,628 (-3,491 to 8,746)	.400
Duration of injury				
0-10 years[a]				
10-20 years	-5.37 (-7.82 to -2.92)	<.001	-10,636 (-14,805 to -6,467)	<.001
>20 years	-3.78 (-6.20 to -1.35)	.002	-2,491 (-7,310 to 2,327)	.311
Unknown	1.23 (-1.88 to 4.33)	.439	-7,890 (-12,790 to -2,990)	.002
Travel time to the nearest VA facility, minutes	-0.06 (-0.08 to -0.04)	<.001	-142 (-170 to -114)	<.001
Hospitalized in prior year	18.34 (16.30 to 20.37)	<.001	21,901 (19,181 to 24,622)	<.001
Outpatient visits in prior year	-0.07 (-0.09 to -0.05)	<.001	97 (58 to 137)	<.001
Average household income from zip per $10,000	-0.18 (-071 to 0.35)	.515	964 (-116 to 2,045)	.08
COPD	1.72 (-1.29 to 4.73)	.264	5,482 (1,094 to 9,871)	.014
Depression	4.78 (2.93 to 6.62)	<.001	7,159 (4,336 to 9,983)	<.001
Diabetes	1.06 (-1.30 to 3.42)	.379	7,184 (3,710 to 10,658)	<.001

Note: SCI/D = spinal cord injury/disorder; VA = Veterans Affairs; COPD = chronic obstructive pulmonary disease

[a]Reference category.

[b]Both traumatic and non-traumatic diagnoses were present.

veterans who had more than 40 days of bed rest were excluded from the French et al study, many patients with pressure ulcers were excluded. In studies examining 29 common chronic conditions treated in VA, Yu et al found that treating veterans with SCI/D cost approximately $34,000 annually per patient[27] and that for veterans 65 years of age or older the annual treatment costs were over $38,000,[11] both in 2008 dollars. Of the 29 chronic conditions examined, the annual treatment cost of SCI/D was the highest. Renal failure had the next highest treatment cost per patient at over $29,000 per year

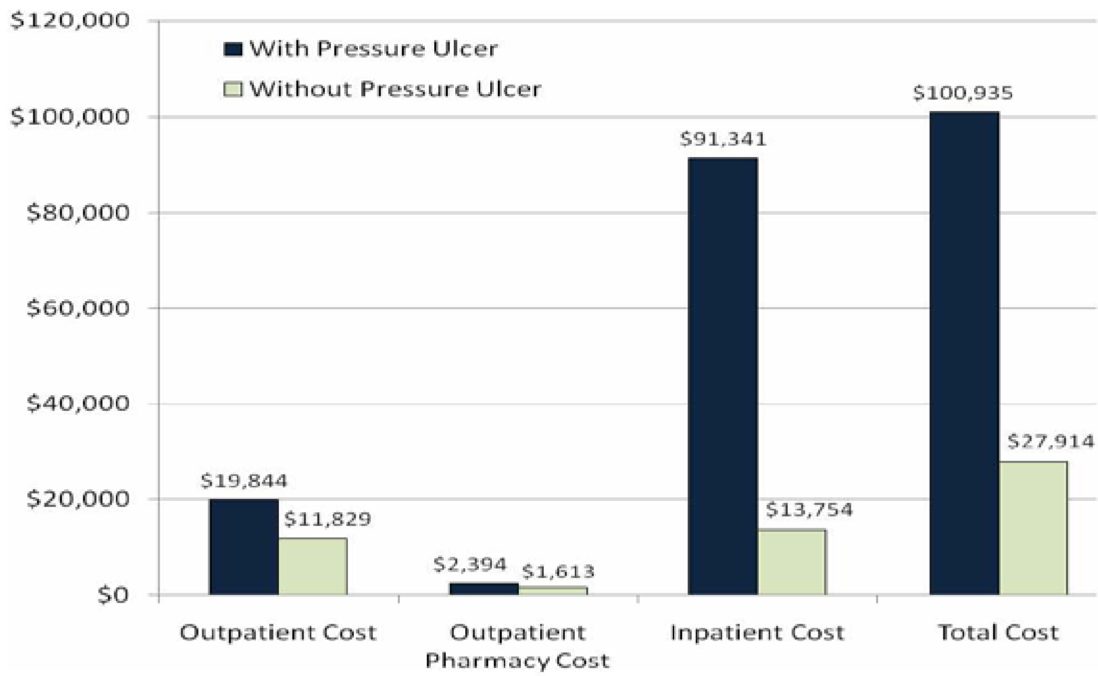

Figure 1. Cost of care per year for veterans with and without pressure ulcers.

followed by dementia at over $25,000 per year in 2008 dollars. Both of these studies have shown that patients with SCI/D have high annual treatment costs; however, neither specifically examined the subset of veterans with pressure ulcers.

Our estimates of the annual costs of patients without pressure ulcers were comparable to annual treatment costs of veterans with SCI/D that have been reported elsewhere.[26,27] Additionally, our findings indicate that annual treatment costs were over 260% higher in the presence of a pressure ulcer among SCI/D patients compared to SCI patients without pressure ulcers. Moreover, the high costs that are associated with an incident pressure ulcer are just one measure of associated illness burden. Pressure ulcers also substantially impact health-related quality of life[28] and increase morbidity and mortality.[3,6,9] In light of these points, developing an evidence base for effective strategies to improve pressure ulcer prevention and treatment should be high priorities for VA.

Our results suggest that VA's SCI/D system of care could benefit from efficient ways to promote early identification and treatment of new skin problems. In this study, veterans with SCI/D who had pressure ulcers averaged $73,021 more in annual treatment costs than veterans without pressure ulcers. This represents over $89 million in total additional costs to the health care system. If interventions to prevent pressure ulcers could be developed that cost approximately $8,000 or less per patient to implement (ie, $89 million divided by 10,997), these interventions might ultimately be cost saving to VA.

By conceptualizing pressure ulcer prevention as an ongoing chronic care self-management activity for persons with SCI/D, steps might be taken before high-cost acute events and other complications occur. For example, patients and/or their informal caregivers could be encouraged to provide routine skin care updates to providers or to report any potential skin problems at the earliest possible opportunity, when immediate intervention by a clinician could positively alter the trajectory of pressure ulcer development and, ultimately, health outcomes. Moreover, increasing access to specialty care through patient-facing technologies (eg, home telehealth applications, personal health record systems) may be a promising approach to extend current resources and further develop a focus on prevention.

Limitations

There are several limitations to this study. First, although we were able to measure the level of injury (paraplegia vs tetraplegia), we were unable to adjust for the completeness of injury as indicated by the International Standards for Neurological Classification of SCI scores due to the substantial portion (>85%) of patients with missing information in our data. Moreover, 7% of patients had an "unknown" level of injury, which was associated with significantly lower total health care costs. We have speculated that the missing level of injury and lower total costs may indicate that these patients are not utilizing VA care as often as other groups. We were also unable to adjust for characteristics of the pressure ulcer itself (number of ulcers, severity, etc). For patients with greater severity of an ulcer (ie, stage I to stage IV), cost, utilization, and mortality risk are also greater. Our results demonstrate, however, that even when early stage (I and II) ulcers are included in the analyses, there is a substantial cost difference between veterans with and without incident pressure ulcers. A second limitation is that only direct VA costs are measured. Because veterans may have other insurance options, such as through Medicare or Medicaid, that might result in non-VA health care use, future studies of Medicare and Medicaid utilization and costs by veterans with SCI will be useful. Moreover, although costs of home-based primary care provided by VA and bowel attendant care covered by VA were included in the cost estimates, non-VA home care and attendant care may also be important for this population but were not measured in this study. Attendant care is the single biggest cost category in the long-term care of persons with SCI,[29] and pressure ulcers will likely increase the need for home care. There is limited research on home care, attendant care, and indirect costs (eg, lost wages, lost productivity) for veterans with SCI/D with pressure ulcers, so additional research would provide important information about the burden of this condition in these areas. Fourth, these costs estimates may not be generalizable to other health care settings because of the differences in how pressure ulcers are managed as well as how costs are measured in other health care systems. Even though veterans with SCI might be admitted to a VA hospital for a pressure ulcer, non-veterans with SCI might be more likely to be admitted to a nursing home if they develop a pressure ulcer. Despite limitations in generalizability to the larger SCI population, this study does provide a vivid picture of the burden pressure ulcers can cause in a health care system in terms of utilization and costs. Fifth, given the cross-sectional design of our analyses, the results presented here must be viewed as associative rather than strictly causal. It is possible that individuals hospitalized or in long-term care for another problem subsequently developed pressure ulcers, which were not responsible for the initial health care use. Additionally, we could have overestimated the real costs of pressure ulcer treatment, because veterans may be admitted for multiple reasons, and pressure ulcer is one of the concurrent diagnoses. Further research would be necessary to disentangle such effects. Finally, this study captured a year's worth of data on incident pressure ulcers. Very long healing times and recurrent pressure ulcers are common in this population, suggesting that costs of treating pressure ulcers are likely higher than we report in our analysis.

Despite these limitations, this study highlights the importance of identifying patients with SCI/D who could be targeted for interventions to decrease the burden of illness associated with pressure ulcers. This is an important step toward developing a better understanding of the costs of care for veterans with SCI/D in the VA and toward being able to develop a more refined research agenda that can help clinicians and policymakers with developing, testing, and implementing more cost-effective treatments for prevention and treatment of pressure ulcers in SCI/D. The VA SCI Quality Enhancement Research Initiative (SCI QUERI), which was established to improve the health and quality of life for veterans with SCI/D by promoting and implementing evidence-based practice, is currently working on projects to improve outcomes by developing and testing a tool to measure wound healing and developing a risk assessment tool to identify patients at greatest risk for pressure ulcer development. Investigators with the SCI QUERI are also evaluating patient self-management programs to decrease pressure ulcer risk. Interventions focused on prevention and early treatment are likely to be the best strategies to reduce health care costs and improve health outcomes in veterans with SCI/D. These initiatives are important steps toward containing the costs of pressure ulcers and ultimately to addressing the overall burden that they pose to veterans, providers, and the health care system.

Acknowledgments

This study was supported by grant IIR 07-188-3 from the Department of Veterans Affairs, Office of Research and Development, Health Services Research and Development Service. The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the US government.

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Changes in Employment Status and Earnings After Spinal Cord Injury: A Pilot Comparison From Pre to Post Injury

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Our purpose was to identify changes in employment status and earnings after spinal cord injury (SCI). Interview data were collected collaboratively at 3 centers designated as SCI Model Systems. The employment rate substantially decreased from 83.3% at injury to 24.5% at follow-up (average of 3.8 years post injury). There were no significant differences in conditional earnings (earnings among those employed) between the 2 times of measurement. However, there was a significant decrease in unconditional earnings (allocating $0 for those unemployed). Those who returned to their preinjury employer (over 60%) reported greater conditional earnings. SCI presents a significant barrier to vocational functioning. **Key words:** *employment, outcomes research, spinal cord injury, vocational rehabilitation*

Traumatic spinal cord injury (SCI) results in immediate and generally permanent losses in sensory and motor functioning, the extent of which depends upon the neurologic level and completeness of injury. Because of the effects on multiple body systems and the need for ongoing vigilance to prevent additional secondary complications, the costs associated with SCI may be extreme. Although a primary concern is the direct cost related to medical care, there are also indirect costs related to the loss of employment and earnings.

Despite a large body of research identifying biographic, injury-related, and educational factors correlated with postinjury employment rates after SCI, we still have a limited understanding of the impact of SCI on labor market participation, particularly how it impacts future earnings. According to Berkowitz et al,[1] indirect costs of SCI may be as much as two-thirds of the direct costs. However, there is very little hard data on SCI earnings, particularly from the last decade.

Three reports in book chapters addressed this issue in the late 1980s and early 1990s. According to the aforementioned 1992 study, Berkowitz et al[1] conducted interviews with 758 participants with SCI in 1988 to establish direct and indirect costs (losses in productivity, including earnings loss from a change in employment status). They found the average indirect cost of SCI was $12,726 per year, with men and persons with quadriplegia reporting greater annual indirect costs than women or persons with paraplegia. DeVivo, Whiteneck, and Charles[2] also analyzed indirect costs related to SCI using a sample from the SCI Model Systems. They calculated annual foregone earnings in 1992 dollars as a function of injury severity and found median earnings loss ranged from $27,867 (Frankel D, functional neurologically incomplete) to $36,003 for those with C1-C4 injuries. The median across all groups was $31,308. The authors attributed the higher figures to a lower employment rate in their sample (25% compared to 35.3% in the Berkowitz study[1]). In a second study by Berkowitz et al,[3] the authors reported an average annual indirect cost of $13,566, with greater costs among men, intermediate age groups (35-54 years), and persons with paraplegia.

Whereas earlier studies focused on indirect costs due to lost employment and earnings, recent research has identified predictors of earnings after SCI without attempting to differentiate pre- and postinjury earnings. In one study, Krause

Top Spinal Cord Inj Rehabil 2011;16(4):74–79

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doi: 10.1310/sci1604-74

and Terza[4] differentiated between conditional and unconditional postinjury earnings, with conditional earnings applying only to those who had been employed after SCI onset and unconditional earnings including all participants, assigning zero earnings to those who had never been employed since SCI onset. There were 615 participants who averaged 17.8 years post injury at the time of assessment. Fifty-seven percent reported no earnings (ie, had not been employed since SCI onset), and only 4% reported earnings of $75,000 or more per year. Whereas several factors were related to unconditional earnings, largely attributable to differential employment rates, the 3 factors most strongly related to conditional earnings were gender, race, and years of education. Men reported $15,946 more in annual conditional earnings, non-blacks reported $19,402 more than blacks, and those with a 4-year college degree reported $35,928 more than those with 12 or fewer years of education.

In a second study, Krause, Terza, and Dismuke[5] conducted similar analyses among a larger sample of 1,296 participants who averaged 15.1 years since injury. Using an expanded data set with more employment variables to serve as statistical controls, they observed similar findings, although the differences in conditional and unconditional earnings attributable to any given characteristic were smaller due to the additional statistical controls. For instance, statistically significant differences were observed in conditional earnings related to gender, race, and education in both studies. However, the amount of conditional earnings attributable to these 3 characteristics decreased from a range of $15,946 to $35,928 in the first study to $11,317 to $21,751 in the second study.

The purpose of this study is to identify changes in employment status and earnings after SCI among a cohort of participants ranging from 1 to 10 years post injury.

Method

Participants

After obtaining institutional review board approval, participants were identified from 3 SCI Model Systems located in the eastern, southeastern, and mountain regions of the United States.* Eligible participants had traumatic SCI of at least 1 year duration and were between the ages of 18 and 64 at the time of their most recent Form II follow-up data collection. The Form II follow-up is a routinely scheduled data collection for SCI Model Systems participants that begins at the first year post injury, with subsequent follow-ups conducted at 5 years and every 5 years thereafter. There were a total of 515 participants who completed materials related to their labor force participation both at the time of injury (form A) and at follow-up (form B).†

The demographic and injury characteristics of the participants were consistent with those typically observed after SCI. Just fewer than 80% of the participants (79.8%) were male. Seventy percent were white non-Hispanic, 20.7% were black non-Hispanic, and 7.3% were Hispanic, white or black (the other 2.1% were other ethnicity). The average age was 36.1 years at the time of their most recent Form II follow-up. A substantial portion of participants were 1-year post injury at the time of assessment (27.6%), and 80% were 5 years or less post injury (an average of 3.8 years had passed since injury onset of the full sample). Just over half of the participants (50.6%) had cervical injuries, with a somewhat greater percentage of C5-C8 (26.8%) compared with C1-C4 (23.6%). The majority of participants (48.1%) had a neurologically complete injury as defined by the international standards for neurological classification of SCI.[6]

Procedures

Data were collected by interview. The majority of follow-up data were collected in conjunction with the standard follow-up data collection in the SCI Model Systems (ie, Form II). Additional questions were added to the overall assessment for those during routine follow-ups at 1, 5, and 10 years post injury. The protocol includes follow-up

* Two additional centers are participating in the study but have not yet accrued sufficient follow-up data for inclusion in the current analysis.

† This study is currently underway, so the participant sample will ultimately increase.

at times not scheduled by the SCI Model Systems at 2, 3, 4, 6, 7, 8, and 9 years post injury. Data were collected using SurveyMonkey, where responses are automatically downloaded into a data file.

Measures

There were 2 sources of data: routine data collected as part of the SCI Model Systems national data set and data on labor force participation from a protocol specifically designed for this study. Biographic and injury variables were obtained from the Form I data collection through the SCI Model Systems. Form I data were collected during the preliminary inpatient rehabilitation hospitalization and consist of biographic, injury status, and other relevant information reflecting the time of injury through discharge. This information was used to describe the participant sample.

Assessment protocols were developed for identifying vocational outcomes both at the time of injury (form A) and at follow-up (form B). Computer-assisted testing was utilized at each data collection site using the SurveyMonkey software. Therefore, the results are automatically entered into a data file and subsequently merged with biographic and injury data. The primary outcome variables of interest were employment status and earnings at injury (baseline) and earnings and employment status post injury.

Form A reflects employment and earnings status at the time of, and prior to, SCI onset. Participants were asked to indicate the amount of earnings, which were presented in group frequencies as follows: (a) less than $10,000, (b) $10,000 to $14,999, (c) $15,000 to $19,999, (d) $20,000 to $24,999, (e) $25,000 to $34,999, (f) $35,000 to $49,999, (g) $50,000 to $74,999, (h) $75,000 to $99,999, and (i) $100,000 or more. Form B reflects current and postinjury employment status and earnings at follow-up.

Analyses

Data were transferred to SPSS (SPSS, Inc, Chicago, Illinois) for analysis. Descriptive statistics were used to summarize the characteristics of the participants in the study, as well as summarize pre- and postinjury employment outcomes. The chi-square statistic was used to identify changes in employment status over time, using the McNemar test to identify differences in the portion of individuals employed on each occasion as well as the portion working less than 40 hours per week, 40 hours per week, or more than 40 hours per week.

We calculated earnings losses by subtracting postinjury earnings from preinjury earnings. Conditional earnings differences reflect only those participants employed on both occasions. In contrast, for analyses including all participants, unconditional earnings were calculated by coding zero dollars for those who were unemployed at either injury or follow-up. Because group frequencies were used to ascertain earnings, we used the midpoint of each category to quantify earnings. Therefore, we used $5,000 as the midpoint for the lowest category of less than $9,999, $12,500 as the midpoint for $10,000 to $14,999, and so on. For the highest category ($100,000 or more), we used the figure $125,000.

Results

Vocational characteristics at injury

The majority of participants were working at the time of injury (83.3%), with only 6.2% of the participants reporting they were unemployed. Of the remaining participants who were not looking for work (9.6% total), 6.2% were in school, 1.9% reported they were retired, 1.9% reported being disabled, and 0.4% reported being homemakers. The majority of employed participants were hourly (52.8%), with another 32.9% salaried and the remaining 14.2% self-employed. The average number of hours worked per week was 45.7 (*SD* 12.3). The majority of participants were working at least full-time, as only 11.3% of those employed at injury reported fewer than 40 hours per week, 40.9% reported working 40 hours per week, and 47.7% reported working more than 40 hours per week. **Table 1** summarizes the portion of individuals in the various earnings categories. Fewer than 40% reported annual income of greater than $50,000 per year. The most frequently reported income range was $35,000 to $49,999

Table 1. Earnings at the time of injury

Earnings	**Percent**	**Cumulative percent**
$0 to $9,999	4.3	4.3
$10,000 to $14,999	5.5	9.8
$15,000 to $19,999	6.3	16.1
$20,000 to $24,999	8.6	24.7
$25,000 to $34,999	13.8	38.5
$35,000 to &49,999	22.7	61.2
$50,000 to $74,999	18.1	79.3
$75,000 to $99,999	9.8	89.1
$100,000 or greater	10.9	100.0

Table 2. Earnings at follow-up among employed participants

Earnings	**Percent**	**Cumulative percent**
$0 to $9,999	7.5	7.5
$10,000 to $14,999	6.5	14.0
$15,000 to $19,999	5.6	19.6
$20,000 to $24,999	8.4	28.0
$25,000 to $34,999	8.4	36.4
$35,000 to $49,999	15.0	51.4
$50,000 to $74,999	15.0	66.4
$75,000 to $99,999	11.2	77.6
$100,000 or greater	22.4	100.0

(22.7%), followed by $50,000 to $74,999 (18.1%) and $25,000 to $34,999 (13.8%).

Vocational characteristics at follow-up

Just 24.5% of the participants reported being gainfully employed at follow-up, 22.7% reported that they were unemployed, and the remaining 52.8% reported that they were not looking for work. The majority of those not looking for work classified themselves as disabled (38.1%), followed by those in school (8.7%), retired (4.9%), and homemakers (1.2%). The average number of hours worked per week was 37.2 (*SD* 14.2). When broken down into categories based on full-time work, 35.6% reported working fewer than 40 hours per week, 28.8% reported working 40 hours per week, and the remaining 36.4% were working more than 40 hours per week. The majority of the participants who were working at follow-up (60.8%) were still working for their preinjury employer. **Table 2** summarizes the salary breakdown of employed participants at follow-up. The percentage of those earning $50,000 or greater was 48.6%, with 22.4% earning over $100,000 per year.

Comparison of preinjury and follow-up status

When grouping participants into employed and not employed (for all reasons), there was a highly significant drop in the portion employed from 83.3% to 24.5% (n = 515; McNemar = 1; $P = .000$). Among those who were working on both occasions, there was a significant decrease in the number of hours spent working from 47.2 to 37.2 ($t_{104} = 7.09$, $P = .000$). When classifying individuals based on the number of hours having worked per week (less than 40, 40, more than 40), over half (51.4%) of employed participants were working more than 40 hours per week at SCI onset, whereas only 33.3% were working more than 40 hours per week at follow-up. Similarly, whereas only 7.6% were working less than 40 hours at injury, 35.2% were working less than 40 hours at follow-up.

There were highly significant differences when comparing unconditional earnings at the time of injury and follow-up (zero earnings for those unemployed) ($t_{423} = 14.1$, $P = .000$). Participants averaged $39,858 annually at injury compared with $14,841 at follow-up. These findings indicate there was, on average, approximately $25,017 in annual earnings lost after SCI. However, when comparing preinjury and follow-up *conditional* earnings (earnings among those employed on both occasions), there were no significant differences between earnings at injury ($66,111) and at follow-up ($61,187) ($t_{98} = 1.25$, NS).

To further help understand earnings change after SCI, we compared conditional earnings as a function of whether the individual returned to their preinjury employer. Significant differences in conditional earnings were observed ($t_{105} = 4.03$, $P = .000$), as those who returned to the preinjury employer averaged $69,467 in annual earnings compared with only $35,781 for those who did not return to their preinjury employer. There were also significant differences in the number of hours worked per week, as those who returned to their preinjury employer averaged 39.7 hours per week compared to only 31.3 for those who did not return to their preinjury employer ($t_{116} = 3.03, P = .003$).

Discussion

The results confirm the substantial decline in earnings resulting after SCI. The size of differences in unconditional earnings pre injury and at follow-up ($25,107) cannot be evaluated in absolute terms compared to previous research given differences in methodology. However, it is clear there were substantial differences in employment rates that accounted for a majority of changes in earnings, as the rate dropped from preinjury status (83%) to 24.5% by follow-up. Nearly a 60% greater portion of those unemployed significantly contributed to the amount of lost earnings. Although the average conditional earnings were not significantly different between the injury onset and follow-up (ie, earnings among those employed on both occasions), it is clear that fewer people were able to maintain full-time employment after SCI onset. Therefore, SCI was associated with lower overall number of hours worked.

An important finding was that a substantial portion of those who were working at follow-up had returned to their preinjury employment and were continuing to work for their preinjury employer at follow-up (60.8%) and their conditional earnings were substantially higher than those who did not return to their preinjury employer. On average, more favorable outcomes in terms of return to work, hours working, and conditional earnings were often attributable to return to the preinjury employer. This is consistent with previous findings suggesting those who return to their preinjury employer do so rather quickly after SCI onset and have professional occupations (as suggested by earnings level in this study).[7,8] However, it must be of concern that such a small portion of those working after SCI onset in the current sample found new jobs after SCI onset. The absence of an opportunity to return to the preinjury employer clearly is a barrier to both the likelihood of working post injury and earnings level.

From a service delivery standpoint, significant efforts should be made to work with employers to make job accommodations so individuals can return to their preinjury employment when possible. This clearly will facilitate better outcomes. However, current findings also suggest that, at least within the first few years post injury, vocational outcomes will be limited among those who do not have the opportunity to return to their preinjury employer, as a result of the limitations of SCI, the nature of the employment, or the willingness of the employer to make SCI-related accommodations.

Limitations

There are several limitations in this study. First, all data are self-report and therefore susceptible to recall bias. We limited reporting of information to those who were no more than 10 years post injury at the time of the study in order to limit recall bias. Second, by virtue of restricting the data collection to participants during the first 10 years post injury, the generalizability of the study is limited to that time frame. Therefore, findings regarding employment rates, return to preinjury employer, and earnings level all must be applied to individuals within the first 10 years post injury and, even more accurately, to those averaging about 4 years post injury. Third, although the study was collected through the SCI Model Systems, only 3 systems contributed sufficient data for the current analysis. Therefore, the results are reflective of individuals in each of those geographic regions (northeastern, southeastern, and mountain regions of the United States). Fourth, earnings were presented as grouped frequencies, and use of the midpoints of categories is only an approximation of actual earnings. Furthermore, for those who earn more than $100,000 per year, we used a relatively arbitrary figure of $125,000 for the calculations. True earnings may deviate substantially among outliers with extremely high income levels. Fifth, at least partially because of the use of categorical schemes, we did not adjust dollar figures to the current value. This may somewhat limit comparisons with existing studies, although such absolute comparisons in earnings losses are often ill advised because of methodological differences between studies. Additionally, the calculations do not include value of lost fringe benefits, health insurance, reduced Social Security benefits, or loss of pension or retirement plans. Last, although longitudinal data are currently being collected, all data reported in the current study are cross-sectional. We simply do not have enough longitudinal data for analysis.

Future research

Additional research is needed to identify how indirect costs of SCI change over time after the first 10 years. Longitudinal research is needed to better quantify changes on an ongoing basis. The SCI Model Systems have been used to generate a national data set, but data on employment and indirect costs are typically limited. Additional variables related to employment and earnings should be included in future revisions of the database. No single source of data will answer all questions on SCI, so investigators need to develop or refine detailed studies of how employment evolves in the years and decades after SCI and the factors affecting different components, including the timeline between injury onset and return to work, work lapses, and early retirement.

Acknowledgments

The contents of this publication were developed under grants H133N060009, H133N060033, H133N060005, and H133N060027from the National Institute on Disability and Rehabilitation Research (NIDRR), US Department of Education. These contents do not necessarily represent the policy of the US Department of Education, and endorsement by the federal government should not be assumed.

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Cost-Effectiveness Analysis of the Spinal Cord Injury Vocational Integration Program (SCI-VIP)

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The Spinal Cord Injury Vocational Integration Program (SCI-VIP) is a 5-year multisite randomized clinical trial to test for differences in employment and rehabilitation outcomes in veterans with spinal cord injury, including a cost-effectiveness analysis. This article provides a review of the background on economic analyses in health care and a description of the methods we will follow for the cost-effectiveness analysis of the SCI-VIP intervention. **Key words:** *cost-effectiveness, spinal cord injury, vocational rehabilitation*

For individuals with spinal cord injury (SCI), return to a preinjury job is unlikely[1] and unemployment is common.[2] Recognizing that most individuals with SCI want to work and believe they are capable of working,[3,4] Ottomanelli et al[5] developed the Spinal Cord Injury Vocational Integration Program (SCI-VIP) to help individuals with SCI return to work. The SCI-VIP study is a 5-year multisite randomized clinical trial that is testing for differences in employment and rehabilitation outcomes in 2 groups of veterans with SCI. The control group received usual care. At the time of the trial, usual care for vocational rehabilitation usually involved referrals to providers outside the US Department of Veterans Affairs (VA) system, mostly to state counselors who are typically responsible for providing services to a large number of individuals with various disabilities. The intervention group received a vocational rehabilitation counseling program called supported employment, which was provided by specially trained Vocational Rehabilitation Counselors (VRC) who are members of the veterans' SCI health care team. Supported employment is a time-intensive and highly personal approach to vocational rehabilitation care based on evidence-based principles. These principles include vocational treatment integrated within the SCI treatment team; rapid engagement (eg, immediate job finding vs testing and assessment); employment in the competitive market; the assumption that employment is possible regardless of severity of injury; ongoing and continuing support after employment has been accomplished; focus on the clients' preferences (eg, job counseling and job services provided with a clients' goals and preferences in mind rather than the counselor's judgments); community-based services (eg, not in treatment or rehabilitations facilities); and personalized benefits counseling.[5-7] The SCI-VIP is patterned after the evidence-based supported employment services that are provided to veterans with serious mental illness under the auspices of the VA's Compensated Work Therapy (CWT) program. In the population with serious mental illness, supported employment has been shown to be an effective vocational rehabilitation approach, but this method has not been previously studied in individuals with SCI or other neuro-musculoskeletal disorders. The details of the design and methods have been published elsewhere.[5]

Top Spinal Cord Inj Rehabil 2011;16(4):80–88

www.thomasland.com

doi: 10.1310/sci1604-80

A secondary objective of the study is to estimate the cost-effectiveness of the SCI-VIP compared to usual care. In this analysis, we will estimate the incremental cost per quality of life year gained with the SCI-VIP compared to usual care. Our hypothesis for this part of the study is that the SCI-VIP is cost-effective when compared to usual care. In the next section, we review the background on cost-effectiveness analyses in health care, after which we describe in more detail the methods we will follow for the SCI-VIP cost-effectiveness analysis.

Background on Cost-Effectiveness Analysis

Most new drugs, procedures, and behavioral interventions are developed because they offer advantages over existing treatments. In rare instances, new technologies are more effective and less expensive than existing options, making the policy decision simple. More typically, however, new technologies are more effective but come with an additional expense. The results of cost-effectiveness analysis (CEA) are used by decision makers with limited resources to better understand the comparative value of the programs they might adopt.

Standards for conducting CEAs were developed in the mid-1990s.[8,9] A CEA requires the calculation of the incremental cost-effectiveness ratio (ICER), in which the numerator is the difference between the average costs in the intervention and control groups, and the denominator is the difference in average health outcomes between these 2 groups.

$$\frac{(\text{Cost}_{\text{intervention}} - \text{Cost}_{\text{usual care}})}{(\text{Outcome}_{\text{intervention}} - \text{Outcome}_{\text{usual care}})}$$

The standard approach in a CEA is to estimate costs using a societal perspective, meaning that all costs, regardless of who incurs them, are included in the cost equation.[8] The societal perspective does not assess how the intervention will affect the decision maker's budget.

In CEA, estimating the costs of a new intervention and identifying total health care costs are frequently a significant challenge. In most areas of life, costs of a good are well-defined and observable because there is a market for it. For example, a person wanting coffee can identify their local suppliers, observe the unit prices (price per cup), and make a decision. However, health care is different; there is no market, in the traditional economic sense, and costs are not easily observable. For example, the hospital bills a patient receives are not the same as the amounts paid by an insurer. Therefore, health economists have developed methods for estimating costs. One method, micro-costing, is often used to estimate the cost of a new intervention. Through a careful enumeration of inputs (labor, supplies, quality assurance, space, and contracting), health economists can determine the quantity of inputs used to produce the intervention. These products can then be combined with unit costs (eg, hourly wages) to estimate the intervention's cost. Micro-costing methods can estimate the cost of an intervention, such as the SCI-VIP intervention, with precision and accuracy. However, micro-costing is time consuming; in some cases, less precise methods, also known as average costing or gross costing, are sometimes preferable. Gross costing uses a national average cost for each encounter or event, thus eliminating variations due to regional differences in labor and supply costs.[8] Gross costing methods are less precise and accurate than micro-costing, but are often sufficient.[10] Estimating costs for an analysis using the societal perspective will include all health care costs, including those of the intervention, and, to capture any downstream changes in health care utilization, other health care services received. Non–health care costs, including costs of travel for the intervention, and costs of unpaid caregiver time are also included in the costs for an analysis using the societal perspective. In many studies, both micro- and gross costing methods are used.

There is ongoing debate about whether to incorporate employment outcomes in the calculation of the ICER, because the loss of employment has immediate financial implications for the person and their family and has implications for their quality of life. However, the standards developed in the 1990s concluded that researchers should exclude the costs of lost employment (or the negative cost of gained employment), because employment outcomes are already captured by the quality adjusted life year (QALY). [8]

Table 1. Quality adjusted life years (QALYs) gained in one subject in the hypothetical interventional arm and one subject in the control arm

Health state	Preference weight *(pw)*	Duration in years in health state *(d)*	QALYs for this health state *(pw*d)*
Interventional arm			
At enrollment	.5	2 months (.167 year)	.084
During PT	.75	6 months (.50 year)	.375
After PT	.85	4 months (.33 year)	.281
Total		1 year	.740 QALYs
Control arm			
At enrollment	.5	12 months (1.0 year)	.500
Follow-up			
Total		1 year	.500 QALYs

Note: PT = physical therapy.

Outcomes in a CEA are often clinical in nature (eg, number of depression-free days in a month, or number of flu cases avoided). A subset of CEA, known as cost-utility analysis (CUA), measures benefits or outcomes in QALYs. The QALY is a comprehensive measure of health outcome, which reflects the patient's health status, his or her preference for that status, and the duration the individual spends in that health state, as reported during the trial.[9, 11] QALYs can range in value from 0 (*death*) to 1 (*perfect health*). Because QALYs gained or lost with an intervention can be compared across heterogeneous programs, with various clinical effects, QALYs are most commonly used for policy purposes.

In the SCI-VIP study, the primary outcome is competitive employment. However, it is not expected that all of the subjects in SCI-VIP will achieve this. It might be expected that the patients who receive the intervention will have improved quality of life when job seeking in addition to when they secure a position. If this is true, then the participants in SCI-VIP will gain QALYs during the job search. Participants in the usual care arm might be encouraged to begin or resume job searching, just because they are participating in the study, and they too might gain improvements in quality of life. If both occur, then a comparison of the QALYs gained during the intervention and follow-up is necessary. In a hypothetical study, subjects are followed for 12 months. In the intervention arm, subjects receive counseling and new treatment, for example, physical therapy. In this arm, the preference weight for the beginning health state might be 0.5; the preference for the health state while receiving physical therapy might be 0.75; and the preference post therapy health state might be 0.85. In the control arm of the study, we assume the preference for the beginning health status is the same (0.5) but remains the same throughout the follow-up period. QALYs will be calculated by multiplying each preference weight by the proportion of the year spent in each state. See **Table 1** for examples.

In the SCI-VIP study, it is assumed that the intervention will be both more effective and more costly than usual care. However, we also know that employment for individuals with SCI is associated with better quality of life than for those unemployed,[12,13] and there is a possibility that veterans who receive the SCI-VIP will use less health care (inpatient hospitalizations, emergency department admissions, etc) than the comparison group. This combination of the cost of the intervention plus the cost of all health care utilization may prove to be less in the intervention arm than in the control arm. Thus, the cost-effectiveness analysis will occur in 2 stages. First, if the intervention is more effective and less expensive, or is less effective and more expensive, then the study will have reached a final conclusion. If the intervention is both more effective and more expensive, we will proceed with the CEA. The ICER describes the cost per QALY gained. If the cost per QALY gained is modest, the intervention will be considered cost-effective.

Cost of the SCI-VIP Intervention

We will estimate the cost of the intervention using micro-costing methods that track the time counselors spend with each veteran. For this purpose, a data collection form was developed and integrated into the VA Computerized Patient Record System (CPRS). The form records the time and type of service provided for the veterans in the intervention arm of the study (**Figure 1**). This form includes information about how the contacts were made and with whom and the type of service provided. These forms are completed by the counselor after every service and are entered into CPRS; they describe the total time the counselor spent providing the intervention. Time and effort data will be combined with average hourly wage of a VA-employed VRC with equivalent credentials to estimate the cost of the VRC's time.[14] In a sensitivity analysis, we will use wage data reported by the US Bureau of Labor Statistics.

Cost of VA Health Care

We will estimate the costs of inpatient and outpatient VA care using gross or average costing methods. Researchers at the VA Health Economics Resource Center (HERC) have used VA cost and utilization data to create national average cost data set for each year since 1998 that include all inpatient and outpatient encounters at a VA medical center.[15,16] By using the VA Average Cost Data, we will be eliminating variation in the cost estimates due to local labor and supply cost differences. VA has another encounter-level data set known as the Decision Support System (DSS). The DSS is an activity-based cost allocation system that produces estimates of the costs of individual inpatient stays or outpatient encounters. As part of our validation, we will compare the Average Cost results to DSS results.

Cost of Non-VA Health Care

Veterans frequently use non-VA providers for health care.[17] Forms to elicit descriptions from the veterans about all health care services they received were developed for each type of health care service (eg, outpatient vocational rehabilitation services, outpatient clinic visits, medical, surgical and psychiatric office visits as well as inpatient or long-term care). These forms include questions about the type of provider the veterans saw, so that we can estimate the cost of the service based on the salary rate of the provider type (**Table 2**). These forms

Table 2. Health care utilization questions for non-VA care

	Question	Answer choices
1	How many times during the past 90 days did you use the resources of a clinic or outpatient care facility (not counting visits only to pick up medication refills)?	0 - None 1 to 7 times 8 - Refused 9 - Don't know
	Please indicate below what kind of resources you received and how/where they were delivered 1.1 Medicine (on-site, phone, and off-site) 1.2 Surgery (on-site, phone, and off-site) 1.3 Psychiatry (on-site, phone, and off-site) 1.4 Dental (on-site, phone, and off-site) 1.5 Physical Medical Rehabilitation (on-site, phone, and off-site) 1.6 Physical Rehabilitation (on-site, phone, and off-site) 1.7 Addictions (on-site, phone, and off-site)	
2	If the answer to **Question 1** is greater than zero (0), → Can you tell me where you got help? Name Address City State Zip code Phone	

VRC Template

☒ Last Name, First Name (000-00-0000) is participating in a research study titled, "A Spinal Cord Injury Vocational Integration Program (SCI-VIP): Implementation and Outcomes" (IRB# 04-094).

1. As part of the clinical services provided through study participation, the Vocational Rehabilitation Counselor (VRC) had contact with (check all that apply):

☐ Veteran
☐ Employer
☐ State Vocational Rehabilitation
☐ Vocational Rehabilitation and Employment
☐ Other: (specify)

2. The contact was (check one):

☐ By Phone
☐ By Email
☐ Face-to-Face

Appointment Date: __ __ / __ __ / __ __ __ __

Appointment Total Length: __ __ __ Minutes

Appointment was:

☐ Attended
☐ No-Showed*
☐ Cancelled*

*If appointment was no-showed or cancelled, do not enter data for sections 3 or 4.

3. The following procedures were conducted (check all that apply):

☐ Orientation / CWT Intake __ __ __ Minutes*
☐ Focused Interview Assessment __ __ __ Minutes
☐ Treatment Plan Development __ __ __ Minutes
☐ Referrals for Collateral Services __ __ __ Minutes
☐ Job Readiness Training __ __ __ Minutes
☐ Job Development __ __ __ Minutes
☐ Vocational Counseling __ __ __ Minutes
☐ Worksite Accommodation __ __ __ Minutes
☐ Job Placement __ __ __ Minutes
☐ Vocational Case Management __ __ __ Minutes
☐ Employment Supports & Job Coaching __ __ __ Minutes
☐ Treatment Plan Review & Revision __ __ __ Minutes
☐ Employment Follow-Up __ __ __ Minutes
☐ Other: (specify) __ __ __ Minutes

*The total of all minutes entered for the activities above must equal the total session minutes entered in section 2 above.

4. Clinical activity(ies) were provided in (check one):

☐ An individual setting
☐ A group setting: total of __ __ patients

Figure 1. Data collection template for the vocational rehabilitation counselors.

Table 3. Travel questions

	Question	Answer choices
1	Mode of transportation to the VA Medical Center from your current address.	1 - By car 2 - By bus/train 3 - By other means
2	Other means of transportation, specified.	1 - VA travel/van 2 - Taxi cab 3 - Medicar 4 - Air 5 - Ambulance
3	Do you drive, or does someone else drive you?	1 - Veteran drove 2 - Other drove
4	Number of hours traveled from your current residence to the VA Medical Center.	
5	Number of minutes traveled from your current residence to the VA Medical Center.	
6	Number of miles traveled from your current residence to the VA Medical Center.	
7	Zip code of other residence lived in the past 90 days.	

are completed by the veterans at every 90-day follow-up visit to describe the care they received in the preceding 90 days. We will use the data from these reports and Medicare reimbursement rates to estimate the cost of non-VA health care.

Non-Health Care Costs

At baseline, the veterans answered questions about their usual mode of travel to the VA medical center where they receive care and the distance traveled. See **Table 3** for these questions. At baseline and at each 90-day follow-up visit, we will ask a series of questions to help quantify the amount of unpaid caregiver time provided to the veterans in the previous months, including time spent transporting the veterans to job seeking and vocational counseling sessions (**Table 4**). Information about the veterans' caregiver time will be estimated from the time reports at each study visit and will be valued using average market payment rate for home health aides performing chore services.

We will estimate each participant's time spent during the intervention and traveling to and from the VA medical center for the intervention, using the federal minimum wage. We will use the participants' reports of time spent in these activities, cross-checked to the counselor reports of the number of trips and the duration of these appointments from encounter reports provided by the counselors. The time the participants spend in the quarterly visits with the study coordinator are research costs and will not be included in the cost calculation.

In addition to the cost of health care, we will estimate the patients' travel expenses associated with each visit. We will estimate travel expenses as the product of distance traveled and the per-mile travel expense for private automobiles[18] using the rate allowed as a tax deduction by the US Internal Revenue Service. **Table 5** illustrates these costing algorithms. QALYs will be estimated from the SF6D instrument,[19,20] which is extrapolated from the VR36, an adaptation of the SF-36 for use with veterans.[21] Subjects also complete the VR36 instrument at each 90-day follow-up visit.

Analysis

The CEA compares the costs and quality of life outcomes for the veterans assigned to the intervention arm with those assigned to the control arm (usual care). The data will be summarized so that there is 1 record per patient from the date of randomization through 1 year. All costs will be converted to a standardized year using the Consumer Price Index (CPI) for all goods. This CPI is preferred over the health care index, which does not adequately control for changes in the

Table 4. Caregiver time questions

	Question	Answer choices
1	Number of hours of paid assistance in a typical 24-hour day that someone provides physical assistance for personal care activities such as eating, bathing, dressing, toileting, and mobility.	
2	Number of hours of unpaid assistance in a typical 24-hour day that someone provides physical assistance for personal care activities such as eating, bathing, dressing, toileting, and mobility.	
3	Number of hours in a typical month that you occasionally have assistance with such things as grocery shopping, laundry, housekeeping, or infrequent medical needs because of the disability.	
4	Person who takes responsibility for instructing and directing your attendants and/or caregivers.	1 - Self 2 - Someone else 3 - Not applicable, does not use attendant care
5	Amount of time someone is with you in your home to assist you with activities that require remembering, decision making, or judgment.	1 - Someone else is always with me to observe or supervise. 2 - Someone else is always around, but they only check on me now and then. 3 - Sometimes I am left alone for an hour or two. 4 - Sometimes I am left alone for most of the day. 5 - I have been left alone all day and all night, but someone checks in on me. 6 - I am left alone without anyone checking on me.
6	Amount of time someone is with you to help you with remembering, decision making, or judgment when you go away from your home.	1 - I am restricted from leaving, even with someone else. 2 - Someone else is always with me to help with remembering, decision making, or judgment when I go anywhere. 3 - I go to places on my own as long as they are familiar. 4 - I do not need help going anywhere.

quality of the goods.[22] We will conduct the CEA using a societal perspective and estimate the ICER for the SCI-VIP compared to usual care. We will conduct sensitivity analyses, varying appropriate input parameters.[8]

Discussion

The SCI-VIP study was implemented at 7 VA medical centers that were selected for geographic location, employment opportunities, and administrative support for the study. Subjects were followed for 12 months, and data collection is now complete. Subjects at 6 of the 7 sites were randomized to the intervention or the comparison group by a biased coin design. One study site was purely observational. Self-reports of both VA and non-VA health care utilization and quality of life surveys have been gathered. QALYs will be estimated from the SF6D instrument, extrapolated from the VR36. The next step is the planned CEA, which will follow widely accepted and recommended methods.[8,9] This article has provided a background in CEA and provided detail on the methods to be used for the SCI-VIP CEA.

Conclusion

The prevalence of spinal cord injury or disorder is estimated at 250,000 to 400,000 in the United States; 22% of these occurrences are in veterans.[23,24] Employment for individuals with SCI is often difficult; in the population enrolled in this study, almost three-quarters (72%) had never been employed post injury.[5] For individuals with SCI, return to gainful employment is the most recognized marker of successful rehabilitation. If this program is proven effective and cost-effective,

Table 5. Costing algorithms

	Cost identification	Source of market valuation	SCI-VIP arm	Control arm
Cost of the intervention	VRC template	Average salary of VA VRC with equivalent credentials	X	
VA and non-VA health care costs	Quarterly self- reports	Service-specific average cost from VA average cost data files	X	X
Costs of travel to intervention/job seeking	Quarterly self- reports	Mileage report x US IRS approved rate for private automobiles	X	X
Time in intervention (including travel to and from)	Quarterly self-reports for travel time;	Federal minimum wage	X	X
	Quarterly self- reports of job seeking and other VR services		X	X
	VRC template for time spent in the intervention/on phone		X	
Unpaid caregiver time	Quarterly report of unpaid care received by veteran	Average market rate for home health aides performing chore services	X	X

Note: VRC = Vocational Rehabilitation Counselor; VR = vocational rehabilitation.

it will likely be adopted by all VA SCI centers and have the potential to impact a large proportion of veterans currently willing and able but not working. The planned CEA will contribute to the policy-making process and to VA operations and planning if the program is adopted.

Acknowledgments

Funding for this study was provided by the Department of Veterans Affairs and was approved by the Stanford Institutional Review Board and the VA Palo Alto Health Care Research and Development program.

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