


## ARTICLE



# Retrospective trends in length of stay and bowel management at discharge from inpatient rehabilitation among individuals with spinal cord injury

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**STUDY DESIGN:** Retrospective observational cohort study.

**OBJECTIVES:** To describe the trend in length of stay (LOS) and its association with the rate of individuals needing total assistance with bowel management upon discharge from inpatient spinal cord injury (SCI) rehabilitation facilities.

**SETTING:** Participants enrolled in the National Spinal Cord Injury Model Systems (NSCIMS) database.

**METHODS:** The NSCIMS database was used to obtain bowel management characteristics from individuals ( $n = 15,975$ ) aged 15 years or older discharged from inpatient rehabilitation facilities between 1988 and 2016 with known demographic factors and LOS. Levels of bowel management were defined from the functional independence measure (FIM) based on the level of assistance required to complete a bowel program. To control for changes in participant population and injury characteristics over the study period, the inverse probability of treatment weight (IPTW) technique was used. Linear and logistic regressions and the Spearman correlation coefficient were used for statistical analyses.

**RESULTS:** The LOS significantly decreased more than  $\frac{3}{4}$  of a day on average each year from 1988 (LOS: 83.16 days) to 2016 (LOS: 50.53 days). Concurrently, the odds of needing total assistance in bowel management at discharge increased 4.1% each year. The correlation between these trends was moderate ( $-0.63$ ). Association analyses yielded that a 1-day decrease in average LOS was associated with a 0.53% increase in those needing total assistance for bowel management at discharge.

**CONCLUSION:** Over the years, as inpatient rehabilitation LOS decreased, rates of those needing total assistance for bowel management at discharge increased.

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## INTRODUCTION

Some of the most common medical complications secondary to spinal cord injury (SCI) interfering with social activities and independence include urinary tract infections, pressure ulcers, spasticity, neuropathic pain, and difficulty with bowel and bladder regulation [1, 2]. In particular, the presence of neurogenic bowel dysfunction (NBD) is often cited as one of the most disruptive conditions, and multiple studies have revealed that individuals with more severe cases of NBD experience significantly worse quality of life and, as a result, poorer long-term survival [3, 4]. Individuals with NBD demonstrate delayed colonic transit, increased or decreased rectoanal tone, and weak abdominal musculature, resulting in fecal retention and constipation. In addition, they are at a significantly high risk of incontinence due to their inability to adequately engage the external anal sphincter and pelvic floor musculature [5]. Current management of NBD requires a bowel program to achieve effective defecation and complete bowel evacuation to prevent further complications [5].

Bowel programs can include digital rectal stimulation, flushing enemas, dietary programs, and medical management [6–8]. However, due to the challenges of elimination, prolonged colonic transit time, impaired mobility, and hand dexterity, large amounts of time are devoted to bowel care programs. Many individuals living with SCI are also dependent on a caregiver to assist with toileting procedures. Such complications associated with NBD can disrupt the ability to participate in rehabilitation and further interfere with engagement in daily activities.

We recently found that most individuals with SCI discharged from inpatient rehabilitation facilities (IRFs) required total assistance with bowel management. This trend significantly increased over time from 1998 to 2016 [9]. We also reported that a shift in bowel management to a more independent classification was attainable years after injury. These results indicate a need for providing continued interventions to support individuals with SCI not only in the immediate years after discharge, where total dependence for bowel management represents the major classification but also well

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into chronic stages following SCI. The annual cost of assistance and support services for people living with SCI is around \$8 billion in the United States alone [10]. These expenditures are allocated to cover the costs of medical care, as well as household assistance, lifestyle modifications, and additional support services required by individuals with SCI [10]. It should also be noted that a significant portion of the expenditures related directly to medical care occurs in the post-acute phase of injury, which is oftentimes when an individual is being discharged into the community [10]. As such, much effort is dedicated towards the rehabilitation of these individuals, with the overall goal being a return to maximum functional level and social participation [2, 11, 12].

Discharge outcomes are highly influenced by the severity of the injury and functional scores upon admission to the inpatient rehabilitation facility, with better functional status at the time of admission being strongly associated with shorter lengths of stay (LOS) [13, 14] and improved long-term prognosis [15]. In theory, a patient is “ready” to be discharged when their functional gains begin to plateau in rehabilitation [16]. In contrast, decreased functional independence measures (FIM) in motor function are attributed solely to the reduced LOS and the reduction in time available to provide patients important skills related to managing SCI sequelae [17–19]. Furthermore, with the changes in the reimbursement model for IRFs from a cost-based system to a prospective payment system (PPS) that occurred in 2002, LOS has steadily decreased over time [2, 10, 16, 20, 21].

In a population of stroke patients, LOS was positively associated with FIM scores at discharge, where each additional day in an IRF resulted in a 0.5 point increase in FIM [22]. A separate study found that, since the introduction of the new Medicare payment model in 2002, there has been a 4.5-day decrease in LOS among stroke patients, along with lower discharge FIM scores and smaller changes in FIM during inpatient stays [23]. Based on the results presented in stroke patients, we hypothesize that the proportion of patients with SCI requiring complete assistance with their bowel program upon discharge from inpatient rehabilitation is negatively correlated with their LOS in rehabilitation. Thus, this paper aims to expand upon these findings by determining an association between decreased average LOS and an increase in the number of individuals with SCI requiring total assistance with their bowel management (as classified by the FIM) at discharge from 1988 to 2016. Given the importance of bowel function to the SCI population as well as the financial aspect of managing numerous chronic issues post-injury, further discussion surrounding this topic and an understanding of clinical best practices for the management of SCI sequelae is important.

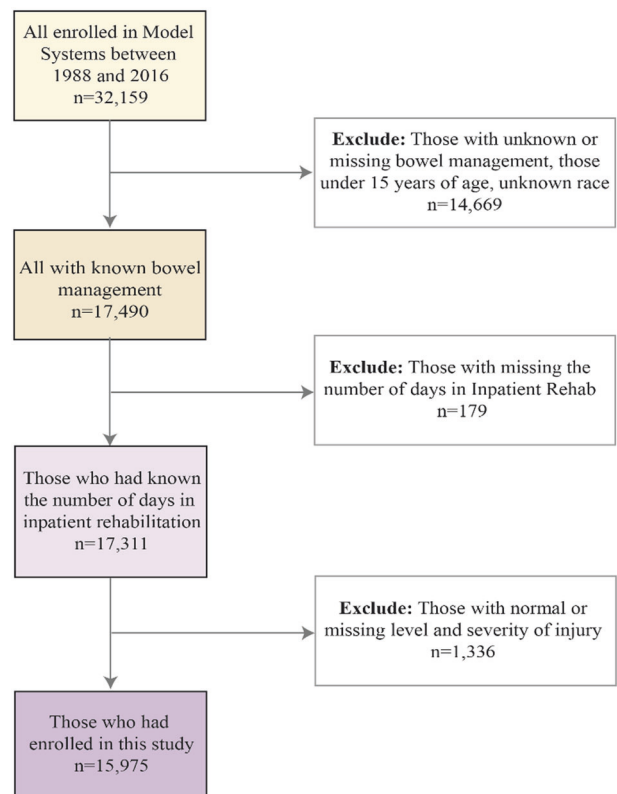
## METHODS

### Data source

Data analyzed in this retrospective observational study was obtained from the National Spinal Cord Injury Model Systems (NSCIMS) database. The NSCIMS database, initiated in 1973, captures data on individuals with SCI prospectively since its inception to establish a baseline for comparison of outcome measures over time and provides comprehensive care information in a Model Systems facility for persons with SCI [24]. Data are organized in two parts for each individual with SCI. Phase one data (Form 1) captures participants’ first enrollment in a Model Systems facility up until discharge, while Phase two (Form 2) includes follow-up data from Years 1, 5, and increments of 5 until Year 40 to date. For the purposes of this study, Form 1 data were used. Note that de-identified data collected from 1973 to 2016 is available to researchers for free after data user agreement signature and approval.

### Study population

This study includes only individuals with SCI who were 15 years and older. Those with unknown age, race, gender, injury year, or LOS at a rehabilitation center were excluded (see Fig. 1 for inclusion and exclusion criteria flowchart).



**Fig. 1** The flow chart for inclusion and exclusion criteria using the National Spinal Cord Injury Model Systems database. The selected study population was refined by excluding individuals ( $n = 16,184$ ) under 15 years of age as well as those with unknown clinical characteristics, demographics, and a lack of bowel management and length of stay data.

### Outcomes of interest

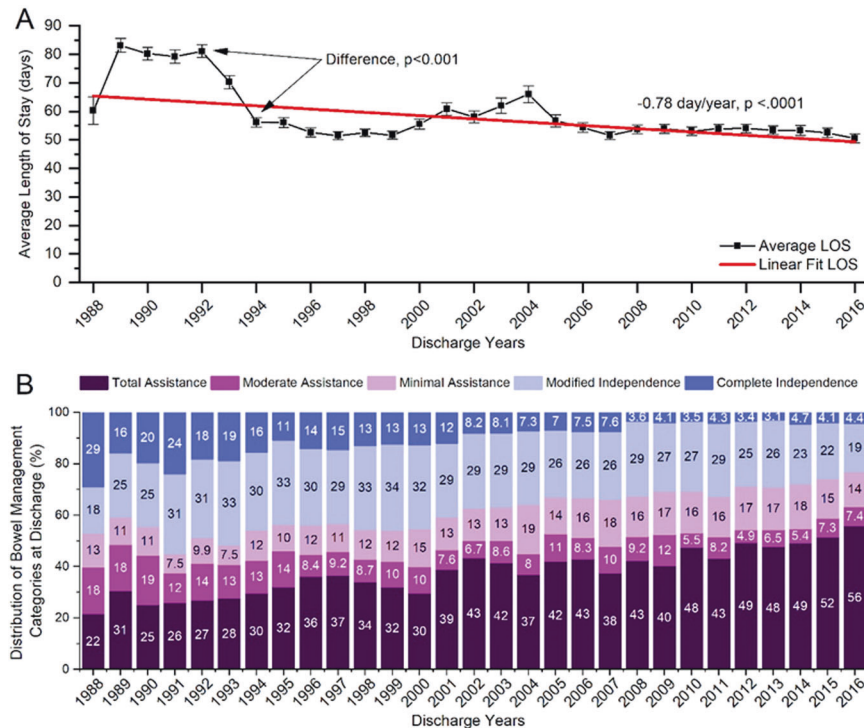
Outcomes of interest were annual average LOS and distribution of bowel management at discharge from the rehabilitation center, trends in LOS and bowel management over the defined years, and the association between the two.

Bowel management is collected as part of the FIM. Different levels of FIM bowel management were grouped to form 5 categories: (1) Complete Independence – complete and intentional control of bowel activity without the use of agents/equipment/assistance and no bowel accidents; (2) Modified Independence – use of agent/equipment is required, but assistance from another individual is not needed and there are no bowel accidents; (3) Minimal Assistance – minimal contact assistance to maintain a satisfactory excretory pattern by using suppositories, enemas, or an external device, the subject performs 75% or more of bowel management tasks; (4) Moderate Assistance – the subject requires moderate assistance to maximal assistance to perform 25–74% of bowel management tasks; (5) Total Assistance – the subject performs <25% of bowel management tasks, or the subject cannot perform the task due to physical or cognitive limitations, and a helper performs the activity for the subject.

Those with unknown rehabilitation LOS or bowel management at discharge were excluded (Fig. 1).

### Descriptive characteristics

Participant demographics included age at the time of injury, sex, and race. Injury characteristics included level of injury (cervical, thoracic, lumbar, sacral, and unknown), the severity of the injury as defined by the American Spinal Injury Association (ASIA) impairment scale (AIS A, B, C, D, E, and unknown), neurologic impairment (paraplegia, tetraplegia, and unknown), and traumatic etiology (8 categories). The analysis sample group was restricted to those with cervical thoracic, and lumbar injuries and those with AIS A, B, C, or D only.



**Fig. 2 Relationship between length of stay and the degree of assistance needed with bowel management over time. A, B** The average length of stay (LOS, in days), and the percent distribution of the bowel management categories each year at inpatient rehabilitation discharge from 1988 to 2016. LOS decreased over time with the largest reduction occurring between 1992 and 1994. Concurrently, the prevalence of total assistance with bowel management significantly increased, and the prevalence of complete independence significantly decreased over time.

### Statistical analysis

Sample descriptive characteristics (demographics and injury descriptors) were all categorical and were summarized with frequency count and associated percentages for included individuals and per year (1988–2016). Comparisons among years were performed using the Chi-squared test. To account for the confounding effect due to the difference in SCI populations over the years, the inverse probability of treatment weight (IPTW) technique was used [25]. In the IPTW method, first, a propensity score (PS) was calculated using a multinomial logistic regression model in which the year was the outcome and all characteristics were included as independent variables. Then, for each individual, the weight was calculated as the sample size adjusted inverse of the propensity of being injured in the year the individual was injured. Post-IPTW characteristic balance was evaluated with *p* values from the IPTW-weighted Chi-square test. Rehabilitation LOS and its change over the years was evaluated with IPTW-weighted linear regression. The discharge functional bowel management category distribution and its change over time were analyzed with IPTW-weighted logistic regression. IPTW-weighted annual LOS and percentage of those discharged needing total assistance were calculated and their correlation was evaluated with the Spearman correlation coefficient. All tests were 2-sided with a significance level of 0.05. Statistical analyses were performed in SAS 9.4 (SAS Inc, Cary, NC).

## RESULTS

### Demographics and injury characteristics

The study sample size included 15,975 individuals who sustained an SCI (see Fig. 1). The study cohort was comprised of individuals who were 68% white, 27% black, and with a majority of males (80%) represented. Those between the ages of 15–44 years made up 66% and those 60 years or older were 14% of the population. Most injuries impacted the cervical spine (55%), followed by the thoracic spine (35%). The majority of individuals were classified as either AIS A (42%) or AIS D (31%), while those classified as AIS B and C constituted 12% and 15%, respectively. Fifty-five percent

(55%) were tetraplegic and the most common mechanisms of injury were vehicular-induced (41%) or accidents (17%).

Over the years, the characteristics (age, race, sex, level of injury, AIS, neurological impairment, and mechanism of injury) of the cohort significantly changed ( $p < 0.05$ , Supplementary Table 1). The distribution of race remained the same from 1988 to 2016. The percentage of individuals who were younger than 44 years decreased from 66% to 54%, while the percentage of individuals older than 44 increased from 34% to 46% from 1988 to 2016 (Supplementary Table 1). The percentage of individuals with cervical injuries increased from 55% to 65%, the percentage of those with thoracic injuries decreased from 35% to 27%, and the percentage with lumbar injuries remained below 10% through these years. The percentage of individuals with AIS A was 42% in 1988 and decreased to 32% in 2016, while those classified as AIS D (31%) in 1988 increased to 41% in 2016. Fifty-five percent (55%) and 65% had tetraplegia in 1988 and 2016, respectively. The most common causes of injury were vehicular (41%) or violence (17%) in 1988, while vehicular (36%) and fall mechanisms of injury constituted (34%) in 2016.

After the inverse probability of treatment weight adjustment, all demographics and injury characteristics were balanced (Supplementary Table 2). The balanced pseudo sample was comprised of 67% white and 27% black; 66% 15–44 year-olds; 80% males; 55% cervical and 35% thoracic injuries; AIS distribution of 42% A, 12% B, 15% C, and 31% D; 55% tetraplegia; and vehicular-induced (42%) and violence (17%) as the main mechanisms of injury.

### Change in rehabilitation LOS over the years

The average rehabilitation LOS was 83.16 days (SE: 2.45) in 1989 and 50.53 days (SE: 1.57) in 2016, corresponding to a reduction of 0.78 days ( $p < 0.0001$ ) in average LOS every year (Fig. 2A). The most significant decrease in LOS was observed from 1992 to 1994:

81.12 days (SE: 2.23) in 1992 to 56.17 days (SE: 1.68) in 1994, ( $p < 0.0001$ ), corresponding to a 31% estimated decrease.

There was a significant change in the distribution of the functional bowel management categories over the years (Fig. 2B). In 1988, the majority of individuals were functionally completely independent at discharge (29.1%). Those who needed total assistance comprised 21.7% of the cohort at that time. Over the years, the percentage of those discharged needing total assistance increased, reaching 55.9% in 2016. This corresponds to an increase of 4.1% in odds of needing total assistance every year (OR: 1.041, 95% CI: 1.037–1.046). At the same time, those discharged who had complete independence decreased to a minority of 4.4% in 2016. Overall, the percentages of those discharged needing minimal and total assistance increased, while those classified as functionally independent (complete and modified) decreased.

### Association between change in LOS and change in bowel management

An average decrease in 1-day rehabilitation LOS was associated with a 0.53% increase in those needing total assistance and a 0.42% reduction in those discharged with complete independence. The correlation between annual average rehabilitation LOS and percent discharged needing total assistance was  $-0.63$  (moderate,  $p$  value: 0.0002).

## DISCUSSION

The results from this study describe a negative association between the number of days spent in an IRF and independence with bowel management, where shorter LOS correlates to a greater degree of assistance needed for completing one's bowel management program (total assistance). We also show a significant decrease in LOS over the years, which is consistent with other studies on the topic [20]. As seen in other SCI population studies, most individuals in our cohort were young males, had cervical injuries, and had tetraplegia. The severity of injury is associated with both LOS and discharge outcomes, with more severe injuries requiring longer LOS and often resulting in poorer outcomes at discharge [13].

The relationship between LOS and functional ability upon discharge has been observed in several other neurologic conditions and impairment groups. As mentioned previously, O'Brien and colleagues found a dose-response relationship between LOS and discharge FIM scores in individuals recovering from a stroke, where longer LOS in an IRF resulted in higher FIM discharge scores [22]. An equivalent relationship was also observed among those with various orthopedic and neurologic conditions and in those with acquired brain dysfunction. Maintenance of rehabilitation LOS was associated with improved outcomes [12, 26]. This relationship makes sense intuitively, as a shorter LOS signifies that patients may be discharged before rehabilitation goals can be met [23].

Based on a literature review, LOS is typically measured as an outcome, with shorter LOS being promoted by the PPS used by both public and private insurers. This payment system was designed to provide hospitals, and later IRFs, with incentives to shorten LOS [23]. After PPS implementation in 2002, rehabilitation LOS was shortened significantly by 5.8 days per year [27]. With individuals being discharged from rehabilitation facilities arguably too early, oftentimes rehabilitation goals are not met and the financial burden is placed on a different source, such as caregivers and family members [23].

We show that LOS is significantly associated with the level of dependence of a bowel management program upon discharge from an IRF. This begs the question – is LOS the best outcome measure to base quality care on? While we are not in a position to answer this question, our results suggest that the current system may incentivize LOS's that are too short to achieve both

rehabilitation and financial goals. Discharging individuals after a shorter LOS may prove economically beneficial in the short term, but could result in a more significant financial burden on the system further on, especially if individuals require more assistance within the community. Following discharge, typical inpatient services may be substituted for home-based or community care that may not be adequate to manage and prevent secondary complications, thus leading to readmission and greater costs to the healthcare system as a whole [28].

We hope that the results of this paper provoke a transition to reimbursement of patient-tailored approaches in the immediate phase following injury, where we have shown that significant and long-lasting improvements in bowel management can occur [9]. These approaches would include educational resources for those with SCI and their caregivers such that the transition from IRF to the community is made easier, thereby reducing the rate of rehospitalization due to medical instability as a result of the shortened LOS. In addition, allowing individuals longer LOS in the immediate phase following their injury would allow for a greater amount of time to recognize difficulties in bowel management early so that significant improvements can be made.

As Ploumis and colleagues present in a previous study, several comorbidities, specifically pressure ulcers, have significant effects on LOS and recovery while in acute care settings and medical care can be influenced by the availability of a model SCI trauma center [29]. Perhaps, the overall reduction in LOS is beneficial at model SCI centers, but not so at non-SCI Level I trauma centers. This presents an intriguing area for further research in providing SCI-specific acute and rehabilitative care.

## LIMITATIONS

We acknowledge that many complex factors contribute to an individual's LOS following SCI. We are limited by what is captured in our dataset, and as such, cannot evaluate the interplay between social dynamics, participation, and recovery. In addition, we are limited in our use of retrospective data which does not allow for control over important variables over time. As such, we can only report observations and recommend that prospective studies be attempted to further explore the relationship between LOS and independence in bowel management.

## CONCLUSION

This study aimed to determine if there was an association between the average LOS in inpatient rehabilitation facilities and the degree of assistance needed for completing one's bowel program among persons with SCI at discharge from 1988 to 2016. We found that the proportion of individuals with SCI requiring complete assistance with their bowel program upon discharge from an IRF is negatively correlated with LOS – i.e., as LOS decreases, the proportion of completely dependent individuals increases. This is consistent with current literature and contributes to the growing body of work concerning long-term rehabilitation outcomes for individuals with SCI. Future research may focus on identifying an optimal LOS, where both providers benefit financially and individuals with SCI benefit functionally. In addition, researchers may focus on the effects of decreasing IRF LOS on different functional modalities and outcomes, with a specific clinical interest in ways to improve the efficiency of rehabilitation while in an inpatient setting.

## DATA AVAILABILITY

Data are available from the corresponding author upon request following prompt review by the University of Louisville Commercialization EPI-Center to verify whether the request is subject to any intellectual property or confidentiality obligations. Any data and materials that can be shared will be released via a Material Transfer Agreement.



## REFERENCES

- van der Meer P. Impact of health problems secondary to SCI one and five years after first inpatient rehabilitation. *Spinal Cord*. 2017;55:98–104.
- Piatt JA. Problematic secondary health conditions among adults with spinal cord injury and its impact on social participation and daily life. *J Spinal Cord Med*. 2016;39:693–8.
- Liu CW. Prediction of severe neurogenic bowel dysfunction in persons with spinal cord injury. *Spinal Cord*. 2010;48:554–9.
- Glickman S, Kamm MA. Bowel dysfunction in spinal-cord-injury patients. *Lancet*. 1996;347:1651–3.
- Stiens SA, Bergman SB, Goetz LL. Neurogenic bowel dysfunction after spinal cord injury: clinical evaluation and rehabilitative management. *Arch Phys Med Rehabil*. 1997;78:586–102.
- Johns J. Management of neurogenic bowel dysfunction in adults after spinal cord injury: clinical practice guideline for health care providers. *Top Spinal Cord Inj Rehabil*. 2021;27:75–151.
- Nelson MES, Orr M. Digital rectal stimulation as an intervention in persons with spinal cord injury and upper motor neuron neurogenic bowel. An evidenced-based systematic review of the literature. *J Spinal Cord Med*. 2021;44:525–32.
- Yeung HY. Dietary management of neurogenic bowel in adults with spinal cord injury: an integrative review of literature. *Disabil Rehabil*. 2021;43:1208–19.
- Dietz N, Sarpong K, Ugiliweneza B, Wang D, Aslan SS, Castillo C, et al. Longitudinal trends and prevalence of bowel management in individuals with spinal cord injury. *Top Spinal Cord Inj Rehabil*. 2021;27:53–67.
- Fiedler IG. Economics of managed care in spinal cord injury. *Arch Phys Med Rehabil*. 1999;80:1441–9.
- Lamontagne ME. Effect of rehabilitation length of stay on outcomes in individuals with traumatic brain injury or spinal cord injury: a systematic review protocol. *Syst Rev*. 2013;2:59.
- Prigatano GP. Prescribed versus actual length of stay and inpatient neurorehabilitation outcome for brain dysfunctional patients. *Arch Phys Med Rehabil*. 1997;78:621–9.
- Tooth L, McKenna K, Geraghty T. Rehabilitation outcomes in traumatic spinal cord injury in Australia: functional status, length of stay and discharge setting. *Spinal Cord*. 2003;41:220–30.
- Osterthun R, Post MW, van Asbeck FW. Characteristics, length of stay and functional outcome of patients with spinal cord injury in Dutch and Flemish rehabilitation centres. *Spinal Cord*. 2009;47:339–44.
- Cohen JT. Association between the functional independence measure following spinal cord injury and long-term outcomes. *Spinal Cord*. 2012;50:728–33.
- Eastwood EA. Medical rehabilitation length of stay and outcomes for persons with traumatic spinal cord injury—1990–1997. *Arch Phys Med Rehabil*. 1999;80:1457–63.
- DeVivo MJ. Sir Ludwig Guttmann Lecture: trends in spinal cord injury rehabilitation outcomes from model systems in the United States: 1973–2006. *Spinal Cord*. 2007;45:713–21.
- Potter PJ. Challenges in educating individuals with SCI to reduce secondary conditions. *Top Spinal Cord Inj Rehabil*. 2004;10:30–40.
- Dobrez D. Impact of Medicare's prospective payment system for inpatient rehabilitation facilities on stroke patient outcomes. *Am J Phys Med Rehabil*. 2010;89:198–204.
- De Vivo MJ. Spinal cord injury. Rehabilitation adds life to years. *West J Med*. 1991;154:602–6.
- Craven BC. Predicting rehabilitation length of stay in Canada: It's not just about impairment. *J Spinal Cord Med*. 2017;40:676–86.
- O'Brien SR. Shorter length of stay is associated with worse functional outcomes for medicare beneficiaries with stroke. *Phys Ther*. 2013;93:1592–602.
- Gillen R, Tennen H, McKee T. The impact of the inpatient rehabilitation facility prospective payment system on stroke program outcomes. *Am J Phys Med Rehabil*. 2007;86:356–63.
- Stover SL, DeVivo MJ, Go BK. History, implementation, and current status of the National Spinal Cord Injury Database. *Arch Phys Med Rehabil*. 1999;80:1365–71.
- Austin PC. An introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivar Behav Res*. 2011;46:399–424.
- Ottenbacher KJ. Trends in length of stay, living setting, functional outcome, and mortality following medical rehabilitation. *JAMA*. 2004;292:1687–95.
- Qu H. Impact of Medicare prospective payment system on acute rehabilitation outcomes of patients with spinal cord injury. *Arch Phys Med Rehabil*. 2011;92:346–51.
- Venkatachalam L, Yazeedi WA, George LA. Predictors of the length of stay of inpatients in rehabilitation setting after traumatic spinal cord injury. *Open Access Sci Rep*. 2012;1:1–9.
- Ploumis A. Length of stay and medical stability for spinal cord-injured patients on admission to an inpatient rehabilitation hospital: a comparison between a model SCI trauma center and non-SCI trauma center. *Spinal Cord*. 2011;49:411–5.

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## AUTHOR CONTRIBUTIONS

AH and BU contributed to concept development and design of the study. RW drafted the manuscript. BU, DW, and SA contributed to data extraction, analysis, and generation of figures and tables. BU conducted the statistical analyses. CC and MB provided clinical interpretation of data. AH and BU supervised the research. RW, BU, SA, and AH also contributed to the interpretation of data. All authors critically reviewed and revised the manuscript.

## COMPETING INTERESTS

The authors declare no competing interests.

## ETHICS APPROVAL

Data for this study received a designation of expedited review by the University of Louisville. Internal Review Board (IRB# 10.0559). All data are de-identified, no PHI is collected and the researchers are not able to link the data to individual identities. We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

## ADDITIONAL INFORMATION

**Supplementary information** The online version contains supplementary material available at <https://doi.org/10.1038/s41393-022-00753-6>.

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