ORIGINAL REPORT

PSYCHOSOCIAL FACTORS ASSOCIATED WITH PROLONGED LENGTH OF STAY IN ACQUIRED BRAIN INJURY REHABILITATION: A RETROSPECTIVE COHORT STUDY

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Objective: **In a climate of rising healthcare costs and increasing pressure to reduce inpatient length of stay, hospitals must balance their role as care providers with that as resource stewards. There is a need to understand what factors are associated with patients staying beyond rehabilitation length of stay targets. The aim of this study was to determine psychosocial patient factors that are identifiable on admission that influence length of stay targets in acquired brain injury rehabilitation.**

Methods: **A retrospective case series of 167 inpatients with acquired brain injury was conducted at an urban, academic rehabilitation hospital. A total of 29 factors were used for data analysis. Logistic and multiple linear regression analysis was utilized to determine if any patient factors were associated with patients exceeding their length of stay targets.**

Results: **Premorbid communal living status (e.g. group home) was associated with an odds ratio of 14.67 of exceeding length of stay target. Patients who did not drive prior to their admission had an odds ratio of 2.63 of exceeding their length of stay target.**

Conclusion: **Premorbid communal living and premorbid non-driving status are predictors of patients with acquired brain injuries exceeding target rehabilitation length of stay. These findings may help acquired brain injury rehabilitation programmes plan for the needs of and advocate for patients.**

LAY ABSTRACT

In the setting of rising healthcare costs, there is a need to understand which patient factors most affect why patients stay longer than anticipated in hospital. The aim of this study was to determine what non-medical factors affect rehabilitation length of stay in patients after brain injuries. A study of 167 patients with brain injuries was conducted at a rehabilitation hospital to determine if any patient factors were associated with patient hospital length of stay. The results show that patients who lived in communal environments, such as group homes, had 14.67 times the risk of exceeding their length of stay target compared to all other living arrangements. Patients who did not drive prior to their admission had 2.63 times the risk of exceeding their length of stay target compared to drivers. In our study, only patient living environments and driving status were predictors of meeting length of stay targets. These findings may help brain injury rehabilitation programmes plan for the needs of and advocate for their patients.

Key words: head injury; rehabilitation; length of stay.

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Acquired brain injury (ABI) is a major cause of morbidity and mortality in Canada. Between 2006–2018, there were 399,376 head-injury-related hospitalizations in Canada (1) and the incidence of new brain injuries requiring hospitalization is projected to increase by 28% by 2031. ABI can cause significant disability and negatively affect a person's quality of life and ability to return to community and work (2). Rehabilitation of people with ABI is important and has been shown to result in improved neurological outcomes (3). Balancing the benefits of additional rehabilitation with the risks and burden of prolonged inpatient hospital stays is an important issue, especially with increasing healthcare costs and ageing demographics (4).

Current literature has identified a variety of factors that can affect the length of stay (LOS) of all types of patients admitted to rehabilitation hospitals. Medical prognostic indicators that have been shown to impact LOS include severity of injury (Glasgow Coma Scale score), abnormal findings on computed tomography, motor and cognitive function score at admission (Functional Independence Measure score), medical comorbidities, age, readmission to acute care, and length of acute care hospitalization (5–15). Socioeconomic status and level of education have also been shown to impact LOS (11, 15). In addition, earlier admission to rehabilitation from acute care has been shown to improve outcomes and reduce inpatient LOS in the ABI population (16). Equitable access to healthcare is one of the domains of healthcare quality that has not been investigated much in the LOS literature cited above (17). Focusing on equity, it is important to investigate the impact of psychosocial factors, such as the presence or absence of social supports, financial income and the type of home dwelling on rehabilitation LOS. Therefore, a retrospective case series study was performed, investigating demographic and psychosocial patient factors that were identifiable on admission to inpatient rehabilitation, and analysing their influence on patient LOS in an ABI rehabilitation unit at a tertiary, urban rehabilitation hospital. No study of this kind has been performed previously in Canada. This study has implications for improving efficiency and equity in ABI rehabilitation practice.

METHODS

Design

A retrospective case series was performed on 167 consecutively admitted patients on the inpatient ABI unit at a tertiary, urban rehabilitation hospital in Toronto, Canada. Patients were admitted between 1 February 2017 and 1 February 2018. A 12-month study period was chosen to enrol approximately 250 patients, based on the hospital's current rate of admissions. The study was approved by the local institutional research ethics board. Due to the retrospective nature of this cohort study, patient consent was waived with Institutional Review Board (IRB) approval.

Participants

All participants were adults who required admission to an inpatient neurocognitive ABI unit at a tertiary, urban rehabilitation hospital in Toronto, Canada. Patients were admitted from a variety of surrounding acute care hospitals with an ABI diagnosis. The neurocognitive unit was a specialized rehabilitation ward for patients with primarily cognitive deficits from their ABI. While admitted, the patients had access to regular visits from a multi-disciplinary team, including a physiatrist, hospitalist, nurse, physiotherapist, occupational therapist, social worker, and speech language pathologist. Target LOSs were established by examining the Canadian Institute for Health Information (CIHI) Rehabilitation Patient Group (RPG) methodology, which uses a patient's primary admission diagnosis, age, admission functional status as measured by Functional Independence Measure (FIM) score and health costs/resource utilization. The CIHI methodology uses data from participating hospitals and a Classification and Regression Tree (CART) analysis to identify distinct groups of patients with similar lengths of stay and resource utilization. There are 6 discrete Rehab Practice Groups for traumatic brain injury patients and 4 Rehab Practice Groups for non-traumatic brain injury (Table I).

Each patient is assessed using the FIM within 72 h of admission to the rehabilitation programme and assigned a target LOS based on the mean LOS for their corresponding CIHI Rehab Practice Group. The patient

Table I. Canadian Institute for Health Information length of stay (LOS) methodology

Rehabilitation Group	RPG	Specification	Rehabilitation cost weight 2017	Short stay trim 2017	Short stay per diem weight 2017	Long stay trim 2017
11–Stroke	1100	M–FIM = 12–38 and Age < = 68	2.5405	4	0.0555	150
	1110	M–FIM = 12–38 and Age > 68	2.0681	4	0.0555	133
	1120	M–FIM = 39–50	1.4077	4	0.0555	75
	1130	M–FIM = 51–84 and C–FIM = 5–25	1.2422	4	0.0555	70
	1140	M–FIM = 51–84 and C–FIM = 26–29	0.9209	3	0.0555	50
	1150	M–FIM = 45–84 and C–FIM = 30–35	0.8009	3	0.0555	51
	1160	M–FIM = 12–84 and C–FIM = 30–35	0.5612	3	0.0555	30
12–Traumatic brain injury	1200	M–FIM = 12–13 and C–FIM = 5–21	8.8637	4	0.0555	333
	1210	M–FIM = 14–27 and C–FIM = 5–21	3.1188	6	0.0555	220
	1220	M–FIM = 48–84 and C–FIM = 5–21	2.5713	4	0.0555	245
	1230	M–FIM = 12–44 and C–FIM = 22–28	2.3163	3	0.0555	168
	1240	M–FIM = 45–84 and C–FIM = 22–28	1.7688	4	0.0555	108
	1250	M–FIM = 12–84 and C–FIM = 29–35	1.0185	3	0.0555	69
13–Non-traumatic brain injury	1300	C–FIM = 5–21	2.7371	4	0.0555	211
	1310	C–FIM = 22–32 and Age < = 61	1.7926	4	0.0555	113
	1320	C–FIM = 22–32 and Age > 61	1.4345	5	0.0555	82
	1330	C–FIM = 33–35	0.8280	3	0.0555	82

RPG: Rehabilitation Patient Group; M-FIM: motor functional independence measure score; C-FIM: cognitive functional independence measure score.

Short Stay Trim = Number of days below which an episode is considered a Short Stay for a given RPG. Lengths of stay less than or equal to this trim value will be considered Short-Stay episodes.

Short Stay Per Diem Weight = Used to weight each patient day for NRS Short-Stay episodes.

Long Stay Trim = Number of days beyond which an episode is considered a Long Stay for a particular RPG. Lengths of stay greater than this trim value will be considered Long-Stay episodes.

is provided with a letter notifying them of their Mean expected target discharge date based on this calculation by the ABI rehabilitation team.

Data collection

Data were abstracted from electronic medical records and the ABI service's handover documents. After patient admissions, 1 in every 10 of the study participant's files were reviewed and compared by members of the research team prior to data collection, to ensure classification reliability. Research team members (AM, MG, AT) created an abstraction form that contained definitions of key terms and classifications for ease of data analysis. Patient characteristics were de-identified and documented in an Excel spreadsheet using the abstraction form. A full list of variables collected is documented in Appendix S1. Traumatic brain injury (TBI) severity was determined utilizing the Department of Veterans Affairs (VA) and Department of Defense (DoD) severity classification system (18). Patients with intracerebral haemorrhages were admitted to the ABI unit if it was determined the cognitive and/or behavioural sequalae post-stroke would be better supported by the rehabilitation therapists on the ABI rehabilitation unit. Common clinical factors that contributed to greater functional deficits requiring ABI rehabilitation admission included surgical interventions and complications such as hydrocephalus. Patients with ischaemic strokes were admitted to the ABI unit if it was determined they had primarily cognitive rather than physical deficits. The "Other" ABI classification was created for the purpose of statistical analyses since none of the included types of ABI had large enough numbers to be included as separate entities. The "Other" ABI subgroup encompassed anoxic brain injuries, ischaemic strokes, and various types of encephalopathies.

Statistical analysis

All descriptive data are presented as mean (standard deviation; SD) and as numbers and percentages when appropriate. The effects of 29 independent variables on LOS were evaluated in separate models using simple and multiple linear regression. First, in a simple linear regression model, those covariates associated with LOS were included. To find the most significant variables and prevent losing important variables, all variables with a significant coefficient at 0.1 levels were entered into a multiple regression model (multiple regression: model 1). In the second multiple hierarchical regression model, the effect of the mechanism of injury was evaluated, considering TBI as the reference group. All significant variables in the first multiple models were entered as a block to find the best-fitted model. In both models, age was considered in the models as a potential confounder.

The LOS data was also dichotomized into 2 patient groups: patients who achieved their target (i.e. LOS was shorter or the same as their target LOS), and patients whose LOS exceeded their calculated target. This was done to evaluate the efficacy of the current LOS estimates, and to identify factors that were associated with patients staying in hospital beyond their LOS targets. Logistic regression analysis was utilized to calculate the association of 29 independent collected variables with the odds of a patient staying beyond their calculated LOS targets. All variables with a significant coefficient at 0.1 levels were entered in a multiple regression model in the next step.

All statistical analyses were conducted using SPSS (Chicago, Illinois, United States) version 23, and a p-value ≤ 0.05 was considered significant. All patients with missing data would be excluded from data analysis for that specific outcome measure.

RESULTS

In total, 167 patients were admitted to the neurocognitive unit between 1 February 2017 and 1 February 2018. Eight patients did not complete their admission assessments and therefore did not have a target discharge date set (e.g. they were transferred to acute

Table II. Psychosocial demographic factors

Demographics	
Age, years, *n*	167
Mean (SD)	52.39 (19.35)
Female sex, *n* (%)	49 (29.3)
Employed at time of accident, *n* (%)	104 (62.3)
Smoker, *n* (%)	40 (24)
Lives alone, *n* (%)	35 (21)
Household income, mean (SD), range, Canadian dollars	33,191.54 (8,510.45), 19,675–59,463
Home within GTA, *n* (%)	125 (81.7)
Bathroom on 1st floor, *n* (%)	117 (70.1)
More than 5 comorbidities, *n* (%)	58 (34.7)

SD: standard deviation; GTA: Greater Toronto Area.

Table III. Clinical demographic factors

Clinical factors	
LOS, mean (SD)	35.74 (33.66)
Admission FIM, mean (SD)	87.00 (16.94)
Discharge FIM, mean (SD)	112.98 (12.63)
Time to rehabilitation, median (IQR)	37.5 (46)
ABI type, *n* (%)	
TBI	90 (53.9)
Tumour	18 (10.8)
Ischaemic stroke	3 (1.8)
Intracerebral haemorrhage	20 (12)
Other	36 (21.6)
TBI severity, *n* (%)	
Non-TBI	77 (46.1)
Mild TBI	13 (7.8)
Moderate TBI	29 (17.4)
Severe TBI	48 (28.7)
History of mental health diagnosis	59 (35.5)

LOS: length of stay; FIM: Functional Independence Measure; ABI: acquired brain injury; TBI: traumatic brain injury.

Table IV. Total length of stay (LOS) linear regression analysis

	Simple Model			Multiple (Model 1)			Multiple (Model 2)		
Variable	β-Coefficient	Standardized β-Coefficients	*p*-value	β-Coefficients	Standardized β-Coefficient	*p*-value	β-Coefficients	Standardized β-Coefficient	*p*-value
Age	0.137	0.226	0.004	0.001	0.001	0.993	–0.98	–0.057	0.484
Female	2.394	0.093	0.235						
ABI type									
TBI	Reference		–				Reference		–
Tumour	0.156	0.001	0.985				–0.680	–0.081	0.935
Intracerebral haemorrhage	–3.389	–0.033	0.635				–2.866	–0.028	0.723
Other ABI	20.737	0.261	0.001				20.938	0.264	0.001
ABI severity									
Non-TBI	Reference								
Mild TBI	–4.307	–0.100	0.224						
Moderate TBI	–0.161	–0.005	0.95						
Severe TBI	–2.459	–0.096	0.26						
Income	–8.39E-05	–0.063	0.445						
Number of comorbidities	0.911	0.193	0.01	0.346	0.073	0.406			
Previous mental health	–1.551	–0.064	0.419						
Employment status	–4.397	–0.0182	0.02	–0.883	–0.037	0.646			
Cohabitation	–0.258	–0.009	0.909						
Admission FIM	–0.347	–0.495	0.0001	–0.328	–0.469	0.0001	–0.368	–0.185	0.022
Non-operative treatment	–4.566	–0.067	0.394						
Intercept	–		–	60.552		0.0001	68.476		0.0001
Adjusted *p*-value	–		–	25.30%		–	10.3%		–

FIM: Functional Independence Measure; ABI: acquired brain injury; TBI: traumatic brain injury.

care due to medical instability before a discharge date was calculated) and were not included in the analysis. Table II details the demographic characteristics of the study population. Table III presents the clinical characteristics of the study population.

The distribution of the LOS was skewed to the right with a mean of 35.74 (±33.66) and a median of 31 days. To meet the assumption of normality of response variable, 3 subjects with extreme values for LOS were deleted from the linear regression mode (Table IV). There were no statistically significant differences between specific types of injury in the simple regression model, compared with the reference of TBI. While the "Other ABI" category did demonstrate a statistical significance in LOS compared with TBI, the heterogenous nature of these diagnoses makes clinical interpretation of this finding challenging. In simple linear regression, increasing LOS was associated with multiple variables, including age, number of comorbidities, employment status and admission FIM.

In the first multiple regression model, the admission FIM and TBI type were variables with a statistically significant impact on LOS. The admission FIM had a regression coefficient of –0.469 (p-value < 0.0001).

In the second heirarchical regression model, the number of comorbidities and employment status were removed because they had non-significant coefficients, and the presence of these 2 variables did not change the adjusted p-values. In this model, admission FIM

Table V. Meeting target length of stay (LOS) logistical regression analysis

Dependent variable: LOS more than predicted

	Model 1 (Simple LR)		Model 2		Model 3	
Independent variables	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Age	1.01 (0.99–1.03)	0.27				
Sex	1.58 (0.70–3.56)	0.42				
ABI type						
TBI	Reference		Reference		Reference	
Tumour	1.11 (0.28–4.37)	0.88	0.92 (0.19–4.45)	0.91	0.91 (0.19–4.35)	0.91
Intracerebral haemorrhage	0.65 (0.13–3.16)	0.60	0.72 (0.13–3.81)	0.70	0.73 (0.14–3.87)	0.71
Other ABI	3.37 (1.39–8.20)	0.007	3.69 (1.33–10.27)	0.012	3.99 (1.45–10.93)	0.007
Home type						
House	Reference		Reference		Reference	
Apartment	1.96 (0.83–4.59)	0.12	1.67 (0.65–4.29)	0.29	1.62 (0.63–4.11)	0.32
Assisted living	14.67 (2.60–82.63)	0.002	11.36 1.70–76.17)	0.012	10.47 (1.58–69.29)	0.02
Admission FIM	0.98 (0.96–1.003)	0.087				
Driving	0.38 (0.17–0.86)	0.02	0.36 (0.14–0.91)	0.03	0.35 (0.14–0.89	0.036
Discharge FIM	0.97 (0.94–0.99)	0.023	0.96 (0.93–1.00)	0.05	0.96 (0.93–0.99)	0.025
FIM efficiency	0.97 (0.94–0.99)	0.50				
Number of comorbidities	1.19 (1.02–1.37)	0.02	1.14 (0.96–1.35)	0.12		

FIM: Functional Independence Measure; ABI: acquired brain injury; TBI: traumatic brain injury.

and "Other ABI" both had statistically significant regression coefficients of –0.368 ($p<0.022$) and 0.264 ($p=0.001$), respectively.

When analysing the data from the perspective of actual LOS compared with target LOS, 30 of the 159 (19%) patients exceeded their targeted LOS. The logistic regression analysis results are detailed in Table V. The 3 outliers excluded in the linear regression were included in the logistic regression. Simple logistic regression demonstrated that type of ABI, premorbid home dwelling type, number of comorbidities, premorbid driving status, and lower discharge FIM had statistically significant impact on the odds of patients exceeding target LOS.

Patients with ABI classification as "Other" had a 3.37 odds ratio (OR) of staying beyond their target LOS ($p=0.007$). In addition, for each additional patient medical comorbidity, there was a slightly increased likelihood of prolonged LOS in the current simple model. This association did not persist in the multiple linear regression analyses.

Only 2 psychosocial factors demonstrated statistically significant associations with LOS targets. Patients who lived in a communal setting, such as a group home, rooming house, or assisted living, prior to their admission had an OR of 14.67 to stay in hospital beyond their target LOS ($p=0.002$). In addition, patients who did not have a driver's licence prior to their ABI had an OR of 2.63 to stay in hospital beyond their target LOS ($p=0.02$). No other psychosocial or medical factors were associated with ABI LOS targets.

A multiple linear regression model outlined the persistent impact of all factors in the simple model, except for medical comorbidities.

DISCUSSION

This study investigated the impact of a variety of medical and psychosocial factors on inpatient ABI sub-acute rehabilitation prolonged LOS in Toronto, Canada. It was hypothesized that psychosocial factors would have an important impact on total LOS and the odds of meeting target LOS. Our logistic regression analysis demonstrated that only 2 psychosocial factors, premorbid driving status and home dwelling type, had an impact on patients meeting their target LOS.

The study findings showed that if patients were in communal living prior to their ABI admission, they had 14 times increased odds of exceeding their LOS target. In these circumstances, discharge from hospital can be a logistical challenge and may not necessarily indicate poor rehabilitation success or FIM efficiency. Awareness of the increased odds of prolonged LOS regarding premorbid home dwellings can allow rehabilitation teams time to prepare earlier for issues regarding discharge destination. In a healthcare system with finite rehabilitation beds and resources, it is paramount for patients to meet target LOS from the perspective of healthcare systems planning. In the scenario where a patient is occupying a rehabilitation bed due to disposition challenges and no longer requires the intensity of rehabilitation, there is inappropriate allocation of resources and other patients awaiting high-intensity ABI rehabilitation do not have access to rehabilitation services during the important early recovery period.

The other psychosocial factor that increased the likelihood of exceeding LOS target was an inactive premorbid driving status. While many ABI rehabilitation patients have their driver's licence suspended due to cognitive or motor sequela after their ABI, premorbid driving status may affect the likelihood of meeting LOS targets because it is a good surrogate marker of premorbid function and socioeconomic status. Specifically, an inactive premorbid driving status may be a marker of premorbid cognitive or physical impairment, which is further exacerbated by the new ABI (19, 20).

Apart from psychological factors, medical prognostic factors in the current cohort included the type of ABI and the patient's number of medical comorbidities. Each additional medical comorbidity had a small, but statistically significant, increase in likelihood of patient's staying in hospital beyond their LOS target. This finding is in keeping with the existing literature in a variety of rehabilitation populations and potentially a function of increased patient medical complexity, frailty, and rehabilitation potential (8). Dividing our ABI cohort into multiple sub-categories of ABI identified the "Other" subgroup as having more than triple the risk of exceeding their LOS targets compared with the TBI, complicated haemorrhagic stroke, and tumour subgroups. The "Other" subgroup also had statistically significant increases in total LOS. The "Other" category included a variety of admitting diagnoses, which did not have a large enough number to be included as individual groups including toxic and metabolic encephalopathies, ischaemic strokes with predominantly cognitive deficits, and anoxic brain injuries. Although this is a very heterogenous subgroup of ABI, the increased likelihood of prolonged LOS may be due to a variety of factors including a lack of team experience treating these much less common types of ABI presentations and potentially reduced or slower rehabilitation potential for these diagnoses. However, the current study was not designed to evaluate this factor. Future research to better delineate their rehabilitation course would be valuable from a clinical and healthcare resource perspective.

The current study also examined how patient factors impacted total LOS. Using multiple linear regressions, the study did not find that any psychosocial factors had a significant impact on total LOS. Similar to the existing literature, multiple medical factors had statistically significant impact on total LOS in the current patient cohort for the simple analysis. The medical factors included ABI type i.e. non-traumatic vs traumatic brain injury, admission FIM, and number of comorbidities (5–15, 21).

In Ontario, Canada, ABI rehabilitation units utilize the Canadian Institute for Health Information's Rehabilitation Patient Group (RPG) grouping methodology for determining target LOSs, which uses patients' age, function on admission as measured by FIM and admission diagnosis to determine target LOSs. The current study's cohort analysis adds evidence to support the use of this current LOS target approach. In fact, in the current multiple linear regression analysis, admission FIM score was the only factor that had a statistically significant impact on total LOS, with the analysis indicating a medium effect size. These results contrast with existing literature that suggest that other medical factors including medical comorbidities, age, readmission to acute care, and length of acute care hospitalization can impact ABI rehabilitation LOS (5–15). Furthermore, no psychosocial factors were identified as having an impact on total LOS.

This study has some limitations. The sample was derived from a single rehabilitation centre, therefore the findings may not be generalizable given the heterogeneity of rehabilitation and funding models internationally. Patients with incomplete data collection were not included in the statistical analysis for their missing variables. Furthermore, 8/167 included patients did not have a set target LOS and therefore were not included in the data analysis all together. In addition, 3 outliers with much longer LOS were excluded from the total LOS data analysis to make it appropriate for linear regression. Patients requiring significant extensions of LOS are especially relevant to our questions of interest, however, could not be included in this statistical analysis. Finally, only the total FIM was used for data analysis. The FIM motor and cognitive breakdown was not utilized, which may be omitting greater granularity of the FIM efficiency, especially on an ABI rehabilitation unit.

In conclusion, premorbid assisted living is a strong predictor of exceeding target LOS. Premorbid non-driving status is also associated with exceeding LOS targets. In our cohort, patients with ABI that were non-traumatic, haemorrhagic, or tumour-related had increased likelihood of exceeding their target LOS. No medical or psychosocial factors, except for admission FIM affected total LOS in the current multiple linear regression analysis. With a lens on health equity, these findings may help ABI rehabilitation programmes plan for the needs of and advocate for patients from communal living settings and point to the need for provincial LOS formulae to consider psychosocial factors, such as home dwelling type.

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