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Original Article

Length of Stay and Home Discharge for Patients with Inpatient Stroke Rehabilitation

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Abstract: ***Objective:*** To examine temporal trends and geographic variations and predict inpatient rehabilitation (IPR) length of stay (LOS) and home discharge for stroke patients. ***Methods:*** Patients aged ≥18 years who were admitted to an IPR facility in Alberta, Canada, between 04/2014 and 03/2018 (years 2014–2017) were included. Predictors of LOS and home discharge were examined using 2014–2016 data and validated using 2017 data. Multivariable linear regression (MLR), multivariable negative binomial (MNB), and multivariable quantile regressions (MQR) were used to examine LOS, and logistic regression was used for home discharge. ***Results:*** We included 2686 rehabilitation admissions between 2014 and 2017. The mean LOS decreased (2014: 71 days; 2017: 62.1 days; $p = 0.003$) during the study period and was shortest in Edmonton (59.1 days) compared to Calgary (66 days) or other localities (70.8 days; $p < 0.001$). Three-quarters of patients were discharged home and this proportion remained unchanged between 2014 and 2017. Calgary patients were more likely to be discharged home than those in Edmonton (OR = 0.62; $p = 0.019$) or other localities (OR = 0.39; $p = 0.011$). The MLR and MNB models provided accurate prediction for the mean LOS (predicted = 59.9 and 60.8 days, respectively, vs. actual = 62.1 days; both $p > 0.5$), while the MQR model did so for the median LOS (predicted = 44.3 days vs. actual = 44 days; $p = 0.09$). The logistic regression resulted in 82.4% of correct prediction, a sensitivity of 91.6%, and a specificity of 50.7% for home discharge. ***Conclusions:*** Rehabilitation LOS decreased while the proportion of home discharge remained unchanged during the study period. Both varied across health zones. Identifiable statistical models provided accurate prediction with a separate patient cohort.

Résumé : Durée de séjour à l'hôpital et obtention d'un congé chez des patients ayant bénéficié d'une réadaptation post-AVC. *Objectif* : Dans le cas de patients ayant été victimes d'un AVC, prédire la durée de leur séjour dans une unité de réadaptation d'un hôpital ainsi que leur obtention d'un congé ; examiner les tendances temporelles et les variations géographiques qui se rapportent à leurs cas. ***Méthodes* :** Nous avons inclus dans cette étude des patients âgés de 18 ans ou plus qui ont été admis au sein d'une unité de réadaptation d'un établissement hospitalier albertain (Canada) entre avril 2014 et mars 2018 (années 2014 à 2017). Les prédicteurs de leur durée de séjour et de leur obtention d'un congé ont été analysés au moyen de données allant de 2014 à 2016. Ces prédicteurs ont ensuite été validés en faisant appel à des données de 2017. Des régressions linéaires multi-variables (RLMV), des régressions binomiales négatives (RBN) et des régressions par quantile (RPQ) ont été utilisées pour examiner la durée des séjours. Quant à l'obtention d'un congé, ce sont des régressions logistiques (RL) qui ont été utilisées. ***Résultats* :** Nous avons inclus un total de 2686 admissions en vue d'une réadaptation, et ce, de 2014 à 2017. La durée moyenne de séjour a diminué au cours de la période à l'étude (2014 : 71 jours ; 2017 : 62,1 jours ; p = 0,003) et s'est avérée la plus brève à Edmonton (59,1 jours) si on la compare à celle de Calgary (66 jours) ou d'autres localités (70,8 jours ; p < 0,001). Les trois quarts des patients visés qui ont obtenu leur congé sont retournés chez eux, cette proportion étant demeurée inchangée de 2014 à 2017. Les patients vivant à Calgary étaient plus susceptibles d'obtenir un congé que ceux vivant à Edmonton (RC = 0,62 ; p = 0,019) ou dans d'autres localités (RC = 0,39 ; p = 0,011). Les modèles de RLMV et de RBN ont fourni des prédictions exactes pour la durée moyenne de séjour des patients (prédiction = respectivement 59,9 et 60,8 jours contre la réalité = 62,1 jours ; les deux p > 0,5) tandis que les modèles de RPQ ont permis de le faire en ce qui regarde la durée médiane de séjour (prédiction = 44,3 jours contre la réalité = 44 jours ; p = 0,09). Enfin, un modèle de RL a permis une prédiction correcte à 82,4 %, une sensibilité de 91,6 % et une spécificité de 50,7 % en ce qui concerne l'obtention d'un congé. ***Conclusions* :** Pendant la période d'étude, on a donc noté que la durée de séjour en réadaptation a diminué tandis que la proportion de congés accompagnés d'un retour à la maison est restée inchangée. Ces deux aspects, nous l'avons montré, ont varié selon l'emplacement géographique. Enfin, rappelons que des modèles statistiques identifiables ont permis une prédiction précise avec une cohorte distincte de patients.

Keywords: Stroke rehabilitation; Stroke

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Introduction

Stroke is a severe health condition and a leading cause of death and disability.[1,2] Almost half of stroke survivors may live with chronic disability for the rest of their lives.[3] It is reported that stroke was associated with about 5.5 million deaths and 116.4 million disability-adjusted life years (DALYs) globally in 2016.[2] The Public Health Agency of Canada estimated that there were approximately 750,000 Canadians living with stroke in 2012.[4] Even though the Canadian stroke rate has been decreasing continuously in the last several decades, approximately 19,000 deaths due to stroke contributed to a total of 290,000 DALYs due to stroke alone in 2016.[2]

Rehabilitation is a critical component of stroke care as many stroke survivors require rehabilitation in an institution or in the community to return to their maximum functional level and to develop the strength, confidence, and cognitive skills to live independently again. Length of stay (LOS) and home/community discharge are regarded as important quality and cost indicators for inpatient rehabilitation (IPR) after an acute care stroke episode and important topics of research to help improve the quality of stroke care.[5,6] Multiple studies have attempted to explore predictors of LOS and discharge destination. A literature search identified 32 studies examining LOS and discharge destination after IPR in the USA, Canada, and other jurisdictions. Overall, 70 and 57 potential risk factors for LOS and discharge destination were evaluated, respectively, across five categories of patient sociodemographic, social/caregiver support, medical, organization/system, and other factors.[7] However, none of these studies has provided a validation benchmark for predictability of identified risk factors.

Accordingly, we conducted a population-based retrospective cohort study of patients receiving IPR after stroke between 2014 and 2017 in Alberta, Canada, where an integrated and publicly funded health care system serves a population of more than four million people in a large and diverse geographic area. We performed two analyses for each of our outcomes: first, we examined temporal trends and geographic variations of rehabilitation LOS and discharge destination for the whole cohort; we then split the whole cohort into modeling (i.e., prediction) and validation cohorts, to examine risk factors that predict rehabilitation LOS and discharge destination.

Methods

Data Source and Study Population

We conducted a population-based retrospective cohort study using linked National Rehabilitation Reporting System (NRS) and Alberta's administrative health databases that include Discharge Abstract Database (DAD) and Alberta Health Care Insurance Plan (AHCIP) Registry.[8,9] The NRS contains complete data on IPR after an acute stroke episode, including patient demographics, admission and discharge Functional Independence Measures (FIM) scores, patient comorbidity, LOS, and discharge destination.[9] The NRS has been used in research,[10] and the available data elements in Alberta's administrative health databases have been described elsewhere.[11,12]

Our study included patients aged ≥18 years who were registrants of the AHCIP and were admitted between 1 April 2014 and 31 March 2018 for rehabilitation in an IPR facility in Alberta within 30 days of an acute stroke episode. The 30-day requirement was based on the recommendation of Accreditation Canada's Stroke Distinction Core Performance Indicator Protocols.[6] The Heart and Stroke Foundation stroke case definitions were used,[5] and cases were identified via relevant International Statistical Classification of Diseases and Related Health Problems [ICD], 10th Revision, codes recorded in the databases (Supplemental Table S1).

The unit of analysis was a single rehabilitation admission; if a patient had more than one rehabilitation admission during the study period, s/he were included multiple times. Consecutive rehabilitation admissions within 24 hours of discharge were counted as a single admission. Based on the admission date, we separated the study period into four equal years from April to March (years 2014–2017). Patients were then categorized into two groups: (1) the modeling cohort, which included patients who started a rehabilitation admission between 2014 and 2016 and (2) the validation cohort, which included patients who started a rehabilitation admission in 2017.

Rehabilitation LOS and its Predictors

We calculated IPR LOS by sex, age group, and health zone and used the modeling cohort (2014–2016) to explore predictors of rehabilitation LOS. We examined distribution of LOS and developed a multiple linear regression (MLR) model with the dependent variable being the natural logarithm of LOS.[10] The covariates were patient's age and admission FIM score, which have consistently been shown to be significantly associated with LOS.[10,13,14] We used the likelihood ratio (LR) test to examine inclusion of additional risk factors with backward stepwise method. They were patient comorbidity, FY of admission, median household income, acute LOS of the associated acute stroke episode, living setting prior to stroke admission, health zone, and IPR facility (Supplemental Table S2). Except for the primary predictors (age and FIM score), a covariate remained in the final model if the LR test results were significant at a 5% level. Model assumptions (homoscedasticity, normality of residuals, and the linearity of relationships between the outcome and continuous predictors, i.e., age, year, and FIM score) were checked for unusual and influential observations by examining residuals and leverage values.

We used the MLR model's coefficients to calculate the predicted LOS for each patient of the validation cohort (2017) and compared the predicted LOS with the actual LOS using the Student's t-test for mean and Kruskal–Wallis test for median. The proportion of variation in the LOS explained by the predictors (adjusted R^2) was also reported.

Discharge Destination after Rehabilitation and its Predictors

Analysis of discharge destination was restricted to patients whose pre-stroke living setting was home and survived the rehabilitation episode. Discharge destination was categorized as home discharge and not-home discharge. We used multivariable logistic regression to examine predictors of home discharge with the modeling cohort (2014–2016). In addition to the list of potential predictors as in the LOS modeling, we examined inclusion of IPR LOS in the final model using the LR test. As the discharge FIM score has been shown to be highly correlated with the admission FIM score, we used only the admission FIM score in the model.[15] Finally, we used the logistic regression model's coefficients to calculate the predicted probability of home discharge for patients in the validation cohort (2017). A patient with >50% chance of home discharge was categorized as predicted home discharge. We then compared the predicted home discharge with the actual home discharge in

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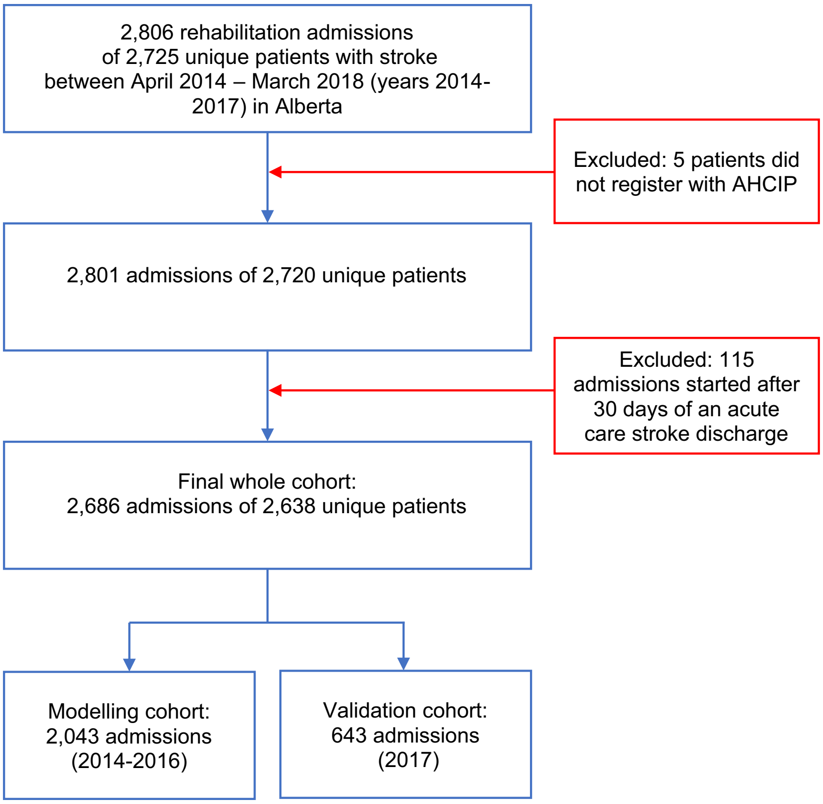

Figure 1: Patient selection flowchart.

the validation cohort and reported sensitivity and specificity of the prediction.

Sensitivity Analysis

We used additional modeling methods to explore the robustness of the results to different estimation approaches to predict the LOS. First, we used negative binomial regression to model LOS as a count variable. Second, we used quantile regression to model the median LOS. In both scenarios, we also used the models' coefficients to calculate the predicted LOS in the year 2017 for the validation cohort and compared it to the actual LOS in that year. In addition, we randomly separated the whole cohort between 2014 and 2017 into two equally sized R1 and R2 cohorts. We used the R1 cohort to model the LOS and used the model's coefficients to calculate the predicted LOS and compared it to the actual LOS of the R2 cohort. We also repeated modeling home discharge using the R1 cohort and validated the home discharge prediction results using the R2 cohort.

Statistical Analysis

Patient characteristics were summarized using means (± standard deviation), medians (interquartile ranges), counts, and percentages, as appropriate. The Student's t-test or Kruskal–Wallis and χ^2 tests were used for comparing continuous and categorical variables, respectively, between the modeling and validation cohorts. Patient median household income was based on the 2016 Canada Census (provided by Alberta Health Services), and patient living location (urban or rural) was based on the second digit of each patient's postal code.[16,17] Previously validated ICD codes were used to identify patient comorbidities and to calculate the Charlson comorbidity score.[18] Comorbidities were considered present if recorded in any diagnostic field at admission for the rehabilitation admission or in any field for hospitalization diagnoses during the 2 years prior to rehabilitation admission.

All analyses were performed using Stata version 14 (Stata Corporation, College Station, Texas); two-sided P values <0.05 were considered statistically significant. This study is a part of a large health evidence review on stroke rehabilitation in Alberta, commissioned and funded by Alberta Health.

Results

There were 2806 rehabilitation admissions of 2725 unique patients with stroke between April 2014 and March 2018 (years 2014–2017) in Alberta. After excluding five patients who did not register with AHCIP and 115 admissions that started after 30 days of an acute care stroke discharge, the final whole cohort included 2686 rehabilitation admissions of 2638 unique patients in 10 IPR facilities. Of these, the modeling cohort included 2043 admissions and the validation cohort included 643 admissions. Figure 1 presents a flowchart depicting patient selection.

Characteristics of the studied population are presented in Table 1 and Supplemental Table S3. Overall, the mean age was 67.9 years and was lower in the modeling cohort (67.6 years vs. 69.1 years; $p = 0.019$). The proportions of patients who were female (42%) was similar between the two cohorts ($p = 0.835$), as was the proportion of those living in an urban location (overall: 83.1%; $p = 0.657$), the distribution of household income ($p = 0.190$), body mass index (BMI) at admission (median = 25.9; $p = 0.799$), and the admission FIM score (mean = 77.6; $p = 0.884$). The two cohorts had similar comorbidities, of which hypertension (80.9%) and dyslipidemia (39.1%) were the most common. The proportion of patients with right-body stroke (47.2%) was higher in the modeling cohort (48.1% vs. 44.6%; $p = 0.004$).

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Table 1: Characteristics of studied population

Variable	All patients	Modelling cohort (2014–2016)	Validation cohort (2017)	p
Rehabilitation admissions, N	2686	2043	643	
Females, n (%)	1129 (42)	861 (42.1)	268 (41.7)	0.835
Age, in years, mean (SD)	67.9 (14.1)	67.6 (14.3)	69.1 (13.4)	0.019
Age, in years, median (IQR)	69 (59–79)	68 (58–78)	70 (60–79)	0.017
Age group, n (%)				
18–59 years	725 (27)	567 (27.8)	158 (24.6)	0.187
60–69 years	661 (24.6)	511 (25)	150 (23.3)	
70–79 years	691 (25.7)	512 (25.1)	179 (27.8)	
≥80 years	609 (22.7)	453 (22.2)	156 (24.3)	
Urban living location, n (%)	2232 (83.1)	1694 (82.9)	538 (83.7)	0.657
Household income (in $), n, (%)				
0-40,000	128 (4.8)	105 (5.1)	23 (3.6)	0.190
40,000-60,000	339 (12.6)	260 (12.7)	79 (12.3)	
60,000-80,000	493 (18.4)	380 (18.6)	113 (17.6)	
80,000-100,000	603 (22.5)	467 (22.9)	136 (21.2)	
>100,000	1123 (41.8)	831 (40.7)	292 (45.4)	
Comorbidities, n (%)				
Myocardial infarction	327 (12.2)	262 (12.8)	65 (10.1)	0.066
Heart failure	251 (9.3)	195 (9.5)	56 (8.7)	0.525
Peripheral vascular disease	200 (7.5)	152 (7.4)	48 (7.5)	0.983
Hypertension	2173 (80.9)	1639 (80.2)	534 (83.1)	0.112
Atrial fibrillation	640 (23.8)	492 (24.1)	148 (23)	0.580
Dyslipidemia	1,050 (39.1)	804 (39.4)	246 (38.3)	0.619
Dementia	88 (3.3)	69 (3.4)	19 (3)	0.600
Chronic pulmonary disease	378 (14.1)	295 (14.4)	83 (12.9)	0.330
Rheumatoid disease	50 (1.9)	41 (2)	9 (1.4)	0.320
Peptic ulcer	46 (1.7)	39 (1.9)	7 (1.1)	0.162
Liver disease	41 (1.5)	32 (1.6)	9 (1.4)	0.764
Diabetes	847 (31.5)	662 (32.4)	185 (28.8)	0.084
Renal disease	200 (7.5)	157 (7.7)	43 (6.7)	0.401
Cancer	221 (8.2)	172 (8.4)	49 (7.6)	0.520
Metastatic cancer	28 (1)	23 (1.1)	5 (0.8)	0.448
Rehabilitation LOS, day, median (IQR)	45 (31–76)	45 (31–77)	44 (29–71)	0.044
Rehabilitation LOS, day, mean (SD)	65.5 (64.5)	66.5 (64.9)	62.1 (63)	0.127
Admission FIM score, mean (SD)	77.6 (22.6)	77.6 (22.8)	77.5 (21.9)	0.884
Admission FIM score, median (IQR)	78 (62–95)	78 (61–95)	78 (62–94)	0.807
Stroke position, n (%)				
Left body	1094 (40.7)	839 (41.1)	255 (39.7)	0.004
Right body	1269 (47.2)	982 (48.1)	287 (44.6)	
Other	323 (12)	222 (10.9)	101 (15.7)	
Body mass index at admission, median (IQR)	25.9 (22.6–29.8)	25.9 (22.6–29.9)	25.7 (22.7–29.7)	0.799

FIM = functional Independence Measure; IQR = interquartile range; SD = standard deviation.

Inpatient Rehabilitation Length of Stay

The median and mean LOS of the overall cohort were 45 and 65.5 days, respectively (Table 1). Both the mean (2014: 71 days; 2017: 62.1 days; p = 0.003) and the median (2014: 49 days; 2017: 44 days; p = 0.005) LOS decreased during the study period. There was no difference in the mean LOS between sexes (66.1 vs. 65 days; p = 0.675). The youngest patients (18–59 years) had the longest

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mean (83.8 days) and second-longest median (48 days) LOS compared to other groups. Patients in Edmonton zone had the shortest LOS (mean = 59.1 days; median = 42 days; both $p < 0.05$) compared to their counterparts in other health zones (Table 2).

Using the modeling cohort, the MLR model predicting the natural logarithm of LOS included age, admission FIM score, acute care LOS of the acute stroke event, year, urban living location, health zone, and IPR facility, all of which explained 38% of the variation in LOS (Table 3). After adjustment, the expected LOS decreased 4% (about 2.6 days) each year ($p = 0.019$) during the study period and it decreased 1% (about 0.7 days) for each year increment in patient's age ($p < 0.001$). The expected LOS was 0.4% longer (about 0.3 days) for each day increment in the acute care LOS of the acute stroke event while it was 2% (about 1.3 days) shorter for each increment in the admission FIM score (both $p < 0.001$). The variations between zones ($p = 0.016$ comparing Edmonton to Calgary) remained. Extrapolating the MLR model's coefficients to the validation cohort (2017) resulted in a mean predicted LOS of 59.9 days, which was similar to the mean actual LOS (62.1 days; $p = 0.477$). However, the median predicted LOS (51.2 days) was longer than the median actual LOS (44 days; $p < 0.001$) (Table 4).

Discharge Destination after Rehabilitation

After excluding 155 admissions of 154 patients whose pre-stroke living settings were not home as well as five admissions in which patients died during rehabilitation, the discharge destination cohort included 2526 admissions (modelling cohort: 1912 admissions [75.7%]). Overall, home discharge accounted for 1901 (75.3%) of the whole cohort, and the odds for home discharge increased over time (9% annual increase; $p = 0.036$).

Patient characteristics by discharge destination are presented in Supplemental Table S4. Home discharge patients were younger (mean age = 66 vs. 71 years; $p < 0.001$), were less likely to be female (39.1% vs. 46.7%; $p < 0.001$), had fewer cardiovascular comorbidities (myocardial infarction: 11.2% vs. 14.4%; $p = 0.030$; heart failure: 7.7% vs. 11.8%; $p = 0.002$; and atrial fibrillation: 21% vs. 30.1%; $p < 0.001$), and had higher admission FIM score (mean = 83.4 vs. 61.6; $p < 0.001$) as well as discharge FIM score (mean = 108.1 vs. 82.5; $p < 0.001$) compared to their not-home discharge counterparts. Home discharge patients had shorter rehabilitation LOS (median = 42 vs. 78 days; $p < 0.001$), had shorter acute care LOS (median = 12 vs.16 days; $p < 0.001$), and were more likely to live with a spouse or family prior to the stroke incidence (77.8% vs. 60.2%; $p < 0.001$). In addition, there were significant variations in the proportions of home discharge patients between health zones and IPR facilities (Supplemental Table S4).

After risk adjustment, there was no change in the proportion of patients discharged home between 2014 and 2016 ($p = 0.394$; year was excluded in the final discharge destination model). The likelihood of home discharge decreased by 1% for each day increment in the rehabilitation LOS (OR = 0.99; $p < 0.001$), while each increment in the admission FIM score resulted in a 5% higher likelihood of home discharge (OR = 1.05; $p < 0.001$). Compared with living with a spouse/family, living alone was associated with a 68% lower likelihood of being discharged home (OR = 0.32; $p < 0.001$). Likewise, patients who lived in an urban location had a higher likelihood of being discharged home compared with patients in rural areas (OR = 1.62; $p = 0.006$). Patients in Calgary were more likely to be discharged home compared with their counterparts in Edmonton (OR = 0.62; $p = 0.019$) or other zones (OR = 0.39; $p = 0.011$). The logistic regression model could explain 32.7% of the variation in home discharge (Table 5).

Table 2: Inpatient rehabilitation length of stay (in day) by sex, age group, and health zone in Alberta, 2014–2017

Variables	Mean (SD)	Median (IQR)
Sex		
Female	66.1 (64.5)	47 (33–76)
Male	65 (64.5)	45 (30–77)
Age group		
18–59 years	83.8 (93.5)	48 (30–88)
60–69 years	61.9 (59)	44 (31–70)
70–79 years	55.8 (41.9)	43 (30–71)
≥80 years	58.5 (39.9)	49 (32–75)
Health zone		
Calgary	66 (58.2)	50 (31–81)
Edmonton	59.1 (64.4)	42 (31–58)
Other	70.8 (73)	49 (30–77)

Table 3: Predictors of inpatient rehabilitation length of stay in Alberta, 2014–2016, using multiple linear regression model (N = 2043)

Variables	Coefficient (95% CI)	p
Age	−0.006 (−0.009; −0.004)	<0.001
Year of admission	−0.038 (−0.069; −0.006)	0.019
Living location		
Rural (ref)	–	
Urban	0.117 (0.044; 0.190)	0.002
Acute care length of stay of the acute stroke	0.004 (0.003; 0.005)	<0.001
Admission FIM score	−0.016 (−0.018; −0.015)	<0.001
Health zone		
Calgary (ref)	–	
Edmonton	−0.829 (−1.501; −0.158)	0.016
Other	−0.041 (−0.190; 0.109)	0.595
IPR facility		
IPR 01 (ref)	–	
IPR 02	−1.926 (−2.521; −1.332)	<0.001
IPR 03	−0.156 (−0.269; −0.043)	0.007
IPR 04	0.825 (0.152; 1.498)	0.016
IPR 05	−0.318 (−0.535; −0.102)	0.004
IPR 06*	–	
IPR 07	0.008 (−0.149; 0.166)	0.918
IPR 08	−0.176 (−0.342; −0.009)	0.039
IPR 09	1.173 (0.927; 1.420)	<0.001
IPR 10*	–	
Intercept	81.561	

*Coefficient calculation was omitted due to few observations or collinearity. Adjusted $R^2 = 38\%$. Root MSE = 0.5902.

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Table 4: Comparison of predicted and actual inpatient rehabilitation LOS in Alberta

Prediction method	Prediction cohort	Validation cohort	Predicted LOS, day, mean (SD)	Actual LOS, day, mean (SD)	p	Predicted LOS, day, median (IQR)	Actual LOS, day, median (IQR)	p
Multiple linear regression model	Patients admitted in 2014–2016, N = 2043	Patients admitted in 2017, N = 643	59.9 (42.7)	62.1 (63)	0.477	51.2 (39.9–69)	44 (29–71)	<0.001
Negative binomial regression model	Patients admitted in 2014–2016, N = 2043	Patients admitted in 2017, N = 643	60.8 (44.6)	62.1 (63)	0.673	50.4 (38.7–70.3)	44 (29–71)	<0.001
Quantile regression model	Patients admitted in 2014–2016, N = 2043	Patients admitted in 2017, N = 643	48.4 (30.8)	62.1 (63)	<0.001	44.3 (31.6–57.1)	44 (29–71)	0.087
Multiple linear regression model	Randomly selected patient cohort (R1), N = 1343	Randomly selected patient cohort (R2), N = 1343	64.6 (45.8)	65 (63.5)	0.874	54.5 (41.4–75)	45 (31–75)	<0.001

Table 5: Predictors of home discharge in Alberta, 2014–2016, using multivariable logistic regression model (N = 1912)

Variables	Discharge home, n (%)	OR (95% CI)	p
Age	–	0.96 (0.95–0.98)	<0.001
Living location			
Rural (ref)	223 (69.5)	1.0	
Urban	1202 (75.6)	1.62 (1.15–2.28)	0.006
Rehabilitation LOS	–	0.99 (0.98–0.99)	<0.001
Admission FIM score	–	1.05 (1.04–1.05)	<0.001
Informal support required	750 (70.8)	0.51 (0.36–0.70)	<0.001
Pre-stroke living arrangement			
With spouse/family (ref)	1,106 (78.6)	1.0	
Alone	319 (63.2)	0.32 (0.24–0.43)	<0.001
Comorbidity			
Atrial fibrillation	299 (66.6)	0.67 (0.50–0.90)	0.009
Dementia	24 (46.2)	0.41 (0.21–0.83)	0.014
Health zone			
Calgary zone (ref)	667 (78.2)	1.0	
Edmonton zone	422 (78.6)	0.62 (0.41–0.92)	0.019
Other	336 (64.4)	0.39 (0.19–0.81)	0.011
Rehabilitation facility			
IPR 01 (ref)	451 (75.7)	1.0	
IPR 02	1 (33.3)	0.05 (0.003–0.83)	0.036
IPR 03	216 (84.1)	0.49 (0.28–0.86)	0.012
IPR 04*	421 (78.6)	–	
IPR 05	31 (66)	1.21 (0.45–3.24)	0.707
IPR 06*	1 (100)	–	
IPR 07	142 (59.4)	0.95 (0.45–2.01)	0.902
IPR 08	91 (67.9)	1.25 (0.57–2.76)	0.576
IPR 09	23 (69.7)	6.39 (1.88–21.77)	0.003
IPR 10*	48 (72.7)	–	
Intercept		9.32	

*OR calculation was omitted due to few observations or collinearity. Pseudo R^2=32.7%. ROC = 86.8%.

Extrapolating the logistic model's coefficients to the 2017 data resulted in 504 (82.1%) episodes of patients with predicted home discharge, equivalent to a sensitivity of 91.6% and a specificity of 50.7% for home discharge in the validation cohort, thereby correctly identifying 82.4% of the discharge destination in 2017 (Table 6).

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Table 6: Sensitivity and specificity of the home discharge prediction model in Alberta

Prediction cohort	Validation cohort	Actual home discharge	Predicted home discharge		Sensitivity	Specificity
			No	Yes		
Patients admitted in 2014–2016, N = 1912	Patients admitted in 2017, N = 614	No	70	68		50.7%
		Yes	40	436	91.6%	
Randomly selected patient cohort (R1), N = 1263	Randomly selected patient cohort (R2), N = 1263	No	149	169		46.9%
		Yes	73	872	92.3%	

Sensitivity Analysis

Except for minor differences, the negative binomial regression model, the quantile regression model, and the multivariable linear regression with a randomly selected patient cohort (cohort R1) resulted in similar statistically significant predictors, as did the multivariable linear regression model in the base case analysis. Collectively, young patients had longer rehabilitation LOS compared with their older counterparts and patients with higher admission FIM score had lower rehabilitation LOS than those with lower admission FIM score. Patients with longer acute care LOS had slightly longer rehabilitation LOS compared with those with shorter acute care LOS. While the negative binomial model and the multivariable regression model with a randomly selected sample provided a similar mean predicted LOS compared with actual LOS, the quantile regression model projected a similar median LOS in the validation cohorts (Table 4). Detailed results of the negative binomial regression model, quantile regression model, and multivariable linear regression with a randomly selected patient cohort (cohort R1) are presented in Supplemental Tables S5–7, respectively.

Using a randomly selected sample (cohort R1) for home discharge modeling resulted in a prediction sensitivity of 92.3%, a prediction specificity of 46.9%, and correctly identifying 80.8% of home discharge in the other randomly selected cohort (cohort R2) (Table 6). Detailed results of logistic regression model using cohort R1 is presented in Supplemental Table S8.

Discussion

Our population-based retrospective cohort study of 2686 IPR admissions of patients with stroke in Alberta between 2014 and 2017 showed that the mean LOS was 65.5 days while the median LOS was 45 days, and that both the mean and median LOS decreased during the study period and varied across rehabilitation facilities. Consistently across modeling methods, younger patients had longer LOS, patients with higher admission FIM score had shorter LOS, and patients with longer acute care LOS in the preceding acute stroke event had slightly longer rehabilitation LOS. Although the available risk factors could explain only 38% of the variation in LOS, the regression to the mean method (multiple linear and negative binomial regression models) provided an accurate prediction of the mean LOS, while the regression of the median (quantile regression model) provided an accurate prediction of the median LOS in the validation cohorts. Three-quarters of patients were discharged home after rehabilitation, and this proportion remained unchanged during the study period. Patients with longer rehabilitation LOS were less likely, while patients with higher admission FIM score were more likely to discharge home. Further, living with a spouse/family and in an urban location were strong predictors of home discharge. The logistic regression model's effect sizes provided a high sensitivity (92%) and a moderate specificity (51%) to predict home discharge.

The findings of variation in LOS between localities are supported in the literature. In a study using the same NRS database between 2008 and 2009, Grant et al. reported a significant variation in the median LOS between Canadian regions, from a low of 31 days in Ontario to a high of 48 days in Alberta.[10] The higher median LOS reported by Grant et al. may be partly due to the more contemporary patient cohort of our study and may therefore reflect the decreasing trend of LOS over time as reported in both our study and in the literature.[19] In addition, while the model used by Grant et al. explained only 20% of the variation in LOS, our model explained 38% of the variation. The greater ability to explain variation in LOS may result from our inclusion of additional risk factors such as acute care LOS of the acute stroke episode and rehabilitation facilities, whereas Grant et al. included only age, FIM motor score, and geographic region in the model.[10] This finding suggests that the variation occurs not only at the large geographic region level, but also between rehabilitation facilities within a region. However, additional research is needed to identify what characteristics of an IPR facility drive the variation and help health care managers design cost-effective quality improvement programs.

The negative association between rehabilitation LOS and home discharge has previously been reported. Using a cohort of Medicare patients aged ≥65 years between 2002 and 2007 in the USA, O'Brien et al. reported a 0.3% decrease ($p < 0.01$) in the odds of community discharge (vs. discharge to an institution) for each 1-day increment in rehabilitation LOS.[19] In addition, using a more contemporary cohort of patients discharged from IPR facilities in the USA between 2009 and 2011, Camicia et al. found that a longer LOS resulted in less likelihood of community discharge for patients with mild (OR = 0.91; 95%CI = 0.84–0.98) and moderate (OR = 0.94; 95%CI = 0.92–0.96) stroke.[14] However, O'Brien et al. found that a higher admission FIM score was associated with lower odds of community discharge (OR = 0.988; $p < 0.001$), which contradicts our findings as well as that of Camicia et al. (for both, OR > 1).[14,19] The reason for the conflicting results could include the older population (patients aged ≥65 years) and a wider definition of community (home plus other independent residences) in the study by O'Brien et al., and the more contemporary cohort in our study. The assumption of the reasons for the conflicting results is strengthened by the fact that our study and the study by Camicia et al. used the same age criteria (≥18 years), had close study periods (2014–2017 and 2009–2011, respectively), and provided the same results.[14]

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There are a number of reports examining predictors of rehabilitation LOS[10,13,20] and discharge destination[15,21–23] for patients with stroke. Our present study, however, is the first to validate the use of prediction models for both LOS and home discharge using a separate patient cohort. In addition, even though our models resulted in similar predictors to those found in other studies, the results of our different LOS prediction models suggest that the model selected could affect the predicted LOS. For example, the regression to the mean method provides accurate estimates of the mean but not median LOS, just as the regression of the median method provides accurate estimates of the median but not mean LOS. This finding, in combination with the low proportion of variation explained by the LOS model (38%) and the home discharge model (33%), may warrant additional research in risk factors that could accurately predict the rehabilitation LOS and home discharge to the best extent possible. Nevertheless, the validation results suggest these models could be used as a support measure for the rehabilitation team in setting targets for patient discharge.

Using the models' coefficients, we have developed an Excel-based dashboard that the rehabilitation team could use to calculate the predicted rehabilitation LOS and discharge destination, assuming that the trends seen during the study period would continue, and then use this information in discussion of a patient's progress. The dashboard has been provided to Alberta Health. It should be noted, however, that this information should be used as a support tool rather than a "must-achieve" target. An example of a similar tool could be seen in Ontario where rehabilitation patient group (RPG, computed using admission cognitive and motor FIM scores and age[24]) was used to generate median LOS benchmark. Meyer et al. reported a significant reduction in LOS (5.9 days) without compromising functional gain when integrating the LOS benchmark in rehabilitation team discussions. The authors argued that the use of LOS benchmark could help by reminding physicians to consider LOS during patient review and hold them accountable for the efficiency of care they provide.[13] While an effort of applying best practices in stroke rehabilitation with using RPG and transitioning to outpatient rehabilitation for eligible patients has been in place in Ontario since early 2010s, a similar approach has not yet been performed in Alberta, prompting the need for an improvement in stroke rehabilitation in the province.[25] We believe that our dashboard could provide support for such an improvement initiative in stroke care.

Even though this study provides novel insights into rehabilitation LOS and discharge destination of patients with stroke, there are several limitations to consider. First, this study is based on administrative data sets, which did not include clinical data of the acute stroke episode that could be associated with lengthen LOS (e.g., the severity of specific impairments such as ataxia or aphasia which may not be fully captured in the FIM score[20]). Second, we did not have data on IPR facility factors such as staffing, rehabilitation team composition, the amount of time spent in therapy, and availability of early supported discharge; it has been reported previously that rehabilitation team composition could be a significant predictor of LOS.[26] The fact that our models could explain only 38% and 33% of the variation in LOS and discharge destination, respectively, indicates that there are other factors influencing LOS and discharge destination that have not been considered in our study. Lastly, we used data from April 2014 to March 2018 in the present study, and we therefore urge for cautions when interpreting the results with regard to more recent stroke rehabilitation practice.

Conclusion

Our population-based retrospective cohort study of patients receiving inpatient stroke rehabilitation in Alberta established that the median and mean of rehabilitation LOS were 45 and 65.5 days, respectively. Three-fourths of the patients were discharged home after rehabilitation. While the rehabilitation LOS decreased, the proportion of home discharge remained unchanged during the study period. Lower age, higher admission FIM score, and longer acute care LOS of the acute stroke event were associated with longer rehabilitation LOS, while patients with lower age, higher admission FIM score, shorter rehabilitation LOS, and living with family and in an urban location were more likely to discharge home after rehabilitation. However, both models for LOS and home discharge did not fully explain the variation of the respective outcome. Additional research is needed to address these gaps.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/cjn.2021.238.

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Statement of authorship. DT, CY, SD and JR conceptualized the study. CY secured data access. DT carried out analyses and drafted the manuscript. All the authors contributed to the writing. All the authors critically reviewed the manuscript for intellectual content.

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