J Rehabil Med 2021; 53: jrm00208

ORIGINAL REPORT

HOSPITAL READMISSION IN STROKE SURVIVORS ONE YEAR VERSUS THREE YEARS AFTER DISCHARGE FROM INPATIENT REHABILITATION: PREVALENCE AND ASSOCIATIONS IN AN ASIAN COHORT

Matthew Rong Jie TAY, MRCP
From the Department of Rehabilitation Medicine, Tan Tock Seng Hospital, Singapore

Objective: **To examine the prevalence and risk factors for readmission after inpatient rehabilitation in stroke survivors, in a developed multi-ethnic Southeast Asian country.**
Methods: **A retrospective cohort study of 1,235 stroke survivors who completed inpatient rehabilitation in a tertiary rehabilitation centre.**
Results: **A total of 296 (24.0%) patients with stroke were readmitted within the first year, and 87 (7.0%) patients were readmitted 1–3 years after stroke. Significant risk factors for readmission of patients in the first year post-stroke were older age ($p = 0.027$), lower admission Functional Independence Measure (FIM) motor ($p = 0.001$) and cognition scores ($p = 0.025$), a Charlson Comorbidity Index (CCI) ≥1 ($p < 0.001$) and the presence of at least one medical complication during initial hospitalization ($p < 0.001$), while FIM gain was found to be protective ($p < 0.001$). Looking at readmission after 1 year post-stroke, a CCI ≥1 ($p < 0.001$) and the presence of medical complications during initial hospitalization ($p < 0.001$) were risk factors for readmission, while FIM gain ($p = 0.001$) was protective. Common causes for readmission include recurrent stroke and falls.**
Conclusion: **There is a high readmission rate in stroke survivors, even after the first year post-stroke. Interventions, such as fall risk assessments, vaccinations, meticulous catheter care, intensified secondary risk factors interventions and continued post-discharge rehabilitation, may hold promise for reducing readmission rates.**

Key words: patient readmission; stroke rehabilitation; stroke; cerebral haemorrhage; risk factors; treatment outcome.

Accepted May 28, 2021; Epub ahead of print Jun 7, 2021

J Rehabil Med 2021; 53: jrm00208

Correspondence address: Matthew Rong Jie Tay, Department of Rehabilitation Medicine, Tan Tock Seng Hospital, Singapore. E-mail: matthew_rj_tay@ttsh.com.sg

LAY ABSTRACT

Readmission of stroke patients results in high morbidity and healthcare costs. Although many studies have examined readmission of stroke survivors in the first year post-stroke, there is a scarcity of studies into readmission after the first year post-stroke, and the effect of rehabilitation on these patients. This study investigated 1,235 patients 3 years post-stroke rehabilitation. Of these patients, 296 (24.0%) were readmitted within the first year, and 87 (7.0%) were readmitted 1–3 years post-stroke. Significant risk factors for readmission included older age, lower functional scores on admission, presence of chronic medical conditions and medical complications during their initial hospital stay. However, functional improvement during inpatient rehabilitation was associated with a reduced readmission rate. This study demonstrates that there is a high readmission rate even after the first year post-stroke. It also highlights the importance of rehabilitation in reducing readmission in stroke survivors.

Patients with stroke admitted to inpatient rehabilitation often have significant neurological dysfunction, resulting in a high risk of readmission for acute care after discharge. Hospital readmissions may indicate unresolved problems, quality of immediate post-hospital care, or a high degree of morbidity, and have a significant impact on healthcare costs (1). Studies also report a relatively high readmission rate between 30 days and 1 year post-stroke. Ottenbacher et al. reported a 30-day readmission rate of 12.7% after discharge from inpatient rehabilitation, based on Centers for Medicare & Medicaid Services data (2), while Zhong et al. reported a pooled 1-year hospital readmission rate of 42.5% in a meta-analysis of patients with stroke in general (1). However, there are few studies investigating the readmission rate of patients with stroke more than one year after discharge from inpatient rehabilitation.

Various risk factors linked to readmission within the first year have been identified in various studies and systemic reviews, including older age, previous history of stroke and cardiovascular disease, diabetes mellitus, length of acute hospitalization and complications during acute stay, compared with control groups who were not readmitted (1–5). Less is known about the long-term risk factors for stroke survivors who survive the first year after stroke without any readmissions, and if these risk factors are different from those previously mentioned. Although a non-white ethnicity has been suggested as a risk factor for readmission (3), this finding may not be applicable to other non-Western populations with different socioeconomic demographics. Several studies have also identified infections, cardiovascular causes, and recurrent stroke as leading causes for readmission within one year after discharge,

doi: 10.2340/16501977-2849

although it is uncertain if these findings are applicable for readmissions beyond 1 year post-event (1).

While pre-stroke and post-rehabilitation functional scores have also been increasingly recognized as significant predictors of readmission (6, 7), this requires further validation, as many of these studies are based on billing or administrative databases, and questions on the reliability, accuracy and completeness of these data remain (8). It is also unclear if functional gains during rehabilitation have a sustained effect on readmission rates beyond 1 year post-stroke.

The aim of this study is to examine the prevalence and risk factors for readmission after inpatient rehabilitation in stroke survivors, within 1 year vs 1–3 years post-stroke, in a developed multi-ethnic Southeast Asian country.

METHODS

Participants

This was a retrospective cross-sectional study of all consecutively admitted patients >18 years of age in the stroke unit at Tan Tock Seng Hospital Rehabilitation Center from 1 Jun 2011 to 1 June 2016. This centre offers tertiary rehabilitation services for the National Healthcare Group of hospitals, one of the largest region-based public healthcare groups.

Patients who were included in the study were admitted for a primary diagnosis of stroke, defined as an acute onset of neurological deficit lasting more than 24 h, of cerebrovascular origin, and confirmed by both clinical and radiological means (9). The diagnosis of stroke was made by emergency room physicians, neurologists or neurosurgeons and confirmed by neuroimaging (computed tomography or magnetic resonance imaging brain scan) within 6 h of acute admission. The type of stroke lesion was classified broadly as either haemorrhagic or ischaemic. Patients who were not Singapore citizens or permanent residents were excluded from the study as they were likely to be lost to follow-up. Other exclusion criteria were patients who died during the index admission or were discharged to palliative care, missing data, patients who were admitted from a facility other than an acute care hospital, rehabilitation length of stay (RLOS) less than 2 days or more than 365 days, or spontaneous subarachnoid haemorrhage and traumatic brain injuries due to differing aetiologies.

Medical charts of patients during their initial hospitalization and subsequent inpatient rehabilitation were reviewed for clinical and demographic information, in-hospital medical complications, admission and discharge dates, movement and treatment during hospitalization. All study patients were followed up for 3 years from the admission day of their initial hospitalization by tracing their electronic records. Any patients with a first unplanned readmission within the study period was defined as a readmission. Visits to the emergency department without admission were not counted as readmissions. RLOS was calculated with the exclusion of any days when there was readmission to acute care.

Clinical data and outcomes

The following clinical data were extracted from medical records: demographics, stroke type, comorbidities, hospitalization stay, rehabilitation stay, discharge destination and presence of caregiver on discharge. Data were also collected on medical complications that occurred prior to and during inpatient rehabilitation.

The recorded reasons for readmission were reviewed from medical records and assigned to categories that best represented the cause of the readmission. In order to avoid counting an episode more than once when more than one reason was provided, clinical judgment and available information were used to reach agreement on the primary reason for each readmission.

Functional status was assessed and scored during inpatient rehabilitation by a multidisciplinary team using the Functional Independence Measure (FIM) score. The FIM score is a widely used 18-item measure of functional status that can be grouped into separate motor (13 items) and cognitive (5 items) domains (10). Each item is scored on a scale ranging from 1 to 7 (dependent to independent). FIM items are then aggregated into motor and cognitive scores, using the 13 motor items to derive the motor score and the 5 cognitive items to develop the cognitive score (10). A motor FIM score range of 13–91 and a cognitive FIM score range of 5–35 are then obtained. Admission and discharge FIM scores were obtained by trained personnel within 72 h of inpatient rehabilitation after transfer from acute stroke units, and prior to discharge from inpatient rehabilitation, respectively.

The Charlson Comorbidity Index (CCI) is a frequently used comorbidity index, which has been validated extensively in adult populations (11). It is calculated based on the presence of 17 common underlying conditions, and was derived from chart review in the current study. It utilizes both the number and impact of individual comorbidities, which were then combined into a composite score according to individual weighted conditions. CCI has been used to determine the prognosis of patients with several medical conditions, and a score of one or more has been shown to predict future morbidity and mortality in various patient groups (12, 13).

Ethics approval was obtained from the institutional review board prior to data collection.

Statistical analysis

Descriptive statistics were utilized to illustrate patient demographics and clinical characteristics. FIM motor scores were categorized into low-functioning (13–38), intermediate-functioning (39–50) and high-functioning (51–91) groups. Similarly, FIM cognitive scores were categorized into low-functioning (5–20), intermediate-functioning (21–29) and high-functioning (30–35) groups (14, 15). FIM gain was expressed in the current analysis per 10-point change in total FIM, to represent clinically significant change in function (16). Comparisons of ordinal data were assessed with the Mann–Whitney *U* test, while categorical and continuous data were analysed using the χ^2 test and the *t*-test, respectively. Bonferroni correction was used for multiple comparisons. A *p*-value <0.05 was considered statistically significant for a 2-tailed test.

Logistic regression analyses were used for the multivariable analyses of whether patients had at least one readmission within one year, as well as readmission at 1-3 years post-stroke. Significant independent variables (age, length of acute hospitalization stay, RLOS, discharge destination, admission FIM motor and cognitive scores, FIM gain, CCI ≥ 1, presence of medical complication during inpatient rehabilitation) were fitted into the model. Patients who were readmitted or dead within one year after discharge were excluded from the analyses on readmission at 1–3 years post-stroke.

Table I. Characteristics of study cohort ($n = 1,235$)

Characteristics	
Age, years, mean (SD)	62.57 (11.86)
Sex, male/female, *n*	788/447
Ethnicity, n (%)	
Chinese	1,018 (82.4)
Malay	129 (10.4)
Indian	79 (6.4)
Others	9 (0.7)
Length of acute hospitalization stay, days, mean (SD)	16.3 (16.9)
Rehabilitation length of stay, days, mean (SD)	33.7 (28.8)
Type of stroke, *n* (%)	
Haemorrhagic	623 (50.4)
Ischaemic	612 (49.6)
Discharge destination, *n* (%)	
Home	1,147 (92.9)
Institutionalization	88 (7.1)
Admission FIM motor score, *n* (%)	
Low functioning 13–38	491 (39.8)
Intermediate functioning 39–50	271 (21.9)
High functioning 51–91	473 (38.3)
Discharge FIM motor score, *n* (%)	
Low functioning 13–38	129 (10.4)
Intermediate functioning 39–50	122 (9.9)
High functioning 51–91	984 (79.7)
Admission FIM cognition score, *n* (%)	
Low functioning 5–20	541 (43.8)
Intermediate functioning 21–29	386 (31.3)
High functioning 30–35	308 (24.9)
Discharge FIM cognition score, *n* (%)	
Low functioning 5–20	267 (21.6)
Intermediate functioning 21–29	353 (28.6)
High functioning 30–35	615 (49.8)
Admission total FIM score, mean (SD)	65.11 (24.96)
Discharge total FIM score, mean (SD)	93.85 (24.39)
FIM gain, mean (SD)	28.75 (18.1)
Charlson Comorbidity Score, n (%)	
0	1,125 (91.1)
1	47 (3.8)
2	26 (2.1)
≥ 3	37 (3.0)
Presence of caregiver	1,099 (89.0)

FIM: Functional Independence Measure; SD: standard deviation.

Data were collected on printed forms and entered into a computer using Excel 2003 (Microsoft Inc., Redmond, WA, USA). Statistical analyses were generated using the Statistical Package for the Social Sciences Version 25.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Study population

A total of 1,158 patients were screened, of whom 23 (2.0%) were not eligible (22 were non-residents and 1 was discharged to palliative care). A total of 383 (31.0%) patients were readmitted over the period of 3 years after the initial stroke event.

The majority of patients were male (63.8%), with 50.4% of patients experiencing a stroke of haemorrhagic origin, and the rest experiencing ischaemic strokes. Baseline characteristics of the total study cohort are shown in Table I.

Medical complications during initial hospitalization

In the study cohort, 414 (33.5%) patients experienced at least one medical complication during their initial inpatient hospitalization. Of these 414 patients, 216 (56.4%) in the readmission group and 198 patients (23.2%) who were not readmitted experienced at least one medical complication during their initial inpatient hospitalization. A majority of patients experienced urinary tract infections (18.1%), psychiatric disorders (11.7%), pneumonia (9.4%), stroke progression (6.9%) and cardiovascular events (5.2%) (Table II).

Prevalence and causes of readmission

A total of 296 (24.0%) patients with stroke were readmitted within the first year post-stroke, and 87 (7.0%) were readmitted 1–3 years after stroke. The causes of readmission within the first year and 1–3 years post-stroke are listed in Table III.

Risk factors for readmission within first year and after 1 year post-stroke

In the multivariate analysis for risk factors resulting in readmission in the first year post-stroke, signi-

Table II. In-hospital medical complications of study cohort during initial hospitalization

Medical complications	All patients ($n = 1,235$)	Readmission ($n = 383$)	No readmission ($n = 852$)
Stroke progression (during acute hospitalization), *n* (%)	70 (5.7)	56 (14.6)	14 (1.6)
Stroke progression (during inpatient rehabilitation), *n* (%)	15 (1.2)	9 (2.3)	6 (0.7)
Seizure, *n* (%)	14 (1.1)	13 (3.4)	1 (0.1)
Cardiovascular/ venous thromboembolism, n (%)	64 (5.2)	47 (12.3)	17 (2.0)
Pneumonia, *n* (%)	116 (9.4)	68 (17.8)	48 (5.6)
Gastrointestinal/hepatobiliary, *n* (%)	36 (2.9)	22 (5.7)	14 (1.6)
Urinary tract infections, *n* (%)	223 (18.1)	102 (26.6)	121 (14.2)
Decubitus ulcer, *n* (%)	29 (2.3)	18 (4.7)	11 (1.3)
Surgical site infections, *n* (%)	3 (0.2)	3 (0.8)	0 (0)
Haematological, *n* (%)	36 (2.9)	26 (6.8)	10 (1.2)
Psychiatric, *n* (%)	145 (11.7)	87 (22.7)	58 (6.8)
Fall, *n* (%)	15 (1.2)	9 (2.3)	6 (0.7)

Table III. Primary causes for readmission

Categories	Readmission within 1 year post-stroke ($n=296$)	Readmission 1–3 years post-stroke ($n=87$)
Recurrent stroke, *n* (%)	59 (10.1)	12 (13.8)
Seizure, *n* (%)	30 (10.1)	1 (1.1)
Neurological[a], *n* (%)	23 (7.8)	5 (5.7)
Neurosurgical[b], *n* (%)	3 (1.0)	1 (1.1)
Fall, *n* (%)	49 (16.6)	11 (12.6)
Pneumonia, *n* (%)	30 (10.1)	14 (16.1)
Cardiovascular/venous thromboembolism, *n* (%)	21 (7.1)	13 (14.9)
Urinary tract infection, *n* (%)	29 (9.8)	7 (8.0)
Skin infection, *n* (%)	8 (2.7)	5 (5.7)
Gastrointestinal/hepatobiliary, *n* (%)	20 (6.8)	5 (5.7)
Orthopaedic, *n* (%)	9 (3.0)	2 (2.3)
Psychiatric, *n* (%)	5 (1.7)	4 (4.6)
Renal, *n* (%)	1 (0.3)	2 (2.3)
Endocrine, *n* (%)	3 (1.0)	0 (0)
Oncological, *n* (%)	1 (0.3)	1 (1.1)
Nutrition, *n* (%)	2 (0.7)	3 (3.4)
Medication, *n* (%)	2 (0.7)	0 (0)
Others, *n* (%)	1 (0.3)	0 (0)
Care, *n* (%)	0 (0)	1 (1.1)

[a]Causes include giddiness, syncope, headache, Bell's palsy, neuropathic pain, dystonia and spasticity.
[b]Causes include hydrocephalus, subdural collection and cranioplasty infections.

ficant factors found were age over 55 years (odds ratio (OR)=1.48; 95% confidence interval (95% CI) 1.05–2.08; $p=0.027$), a FIM motor admission score of <39 (OR=1.78; 95% CI 1.25–2.52; $p=0.001$), a FIM admission cognition score of <20 (OR=1.45; 95% CI 1.05–2.00; $p=0.025$), CCI≥1 (OR=2.88; 95% CI 1.86–4.46; $p<0.001$) and the presence of at least one medical complication during the initial hospitalization (OR=2.84; 95% CI 2.11–3.83; $p<0.001$). Every FIM gain of 10 points was found to be associated with a lower risk of readmission (OR=0.814; 95% CI 0.747–0.887; $p<0.001$). Regarding readmission after 1 year post-stroke, CCI≥1 (OR=23.87; 95% CI 11.97–47.63; $p<0.001$) and the presence of medical complications during initial hospitalization (OR=3.29; 95% CI 2.15–6.45; $p<0.001$) were risk factors, while FIM gain of every 10 points were found to be associated with a lower risk of readmission (OR=0.729; 95% CI 0.615–0.863; $p<0.001$) (Table IV).

DISCUSSION

A readmission rate of 31.0% was reported in the study cohort during 3 years post-stroke, with 24.0% of the patients presenting to hospitals within the first year. Seven percent of stroke survivors who were not admitted within the first year were readmitted during the following 2 years.

The most common causes of readmission were falls, followed by stroke complications and infections. These potentially addressable causes accounted for nearly 60% of readmissions in the first year post-stroke, and for 67.7% of readmissions in the following 2 years post-stroke. Falls are common in people with stroke even after rehabilitation (17), and contributory factors include age, physical impairments and decreased functional mobility (18). It is important to address the factors contributing to falls, and the use of fall risk assessment tools, assessing fall history and balance, gait and physical activity, and appropriate interventions, such as dual-task walking, may be helpful to reduce readmission and morbidity in this population (18,

Table IV. Risk factors for readmission within and after 1 year post-stroke based on multivariate analyses

	Readmission within 1 year post-stroke ($n=296$)			Readmission 1–3 years post-stroke ($n=87$)		
Characteristics	Odds ratio	95% CI	*p*-value	Odds ratio	95% CI	*p*-value
Age >55 years	1.48	1.05–2.08	0.027	1.19	0.645–2.18	0.584
Length of acute hospitalization	1.01	0.998–1.01	0.153	0.982	0.964–1.00	0.050
Rehabilitation length of stay	0.862	0.998–1.01	0.428	0.630	0.989–1.006	0.630
Admission FIM motor score <39	1.78	1.25–2.52	0.001	1.05	0.556–1.99	0.874
Admission FIM cognition score <20	1.45	1.05–2.00	0.025	1.69	0.921–2.96	0.092
Charlson Comorbidity Index ≥1	2.88	1.86–4.46	<0.001	23.87	11.97–47.63	<0.001
Medical complication during initial hospitalization	2.84	2.11–3.83	<0.001	3.29	2.15–6.45	<0.001
Discharge destination (Home)	1.11	0.666–1.86	0.683	1.45	0.542–3.85	0.462
FIM gain of every 10 points during inpatient rehabilitation	0.814	0.747–0.887	<0.001	0.729	0.615–0.863	<0.001

95% CI: 95% confidence interval; FIM: Functional Independence Measure.

19). Infections were a significant cause of readmission, which aligns with existing literature reporting respiratory illness and urinary tract infections as a major cause of readmission (20). Emphasizing preventive care through the use of vaccination (21) and oral hygiene (22) can reduce the risk of readmissions due to community-acquired or hospital-acquired pneumonia. Similarly, catheter use practices can be highly heterogeneous in patients after stroke, and avoidance of unnecessary catheterization, expeditious removal of catheters, and high standards of catheter care (23) may reduce long-term readmission rates due to urinary tract infections. Interestingly, cardiovascular complications were more frequent causes of delayed readmissions after 1 year post-stroke (14.9%), which is similar to the findings of Bjerkreim et al. (24). This reinforces the need for long-term secondary cardiovascular disease prevention and addressing modifiable risk factors (e.g. diet, smoking, physical inactivity, obesity, diabetes mellitus, hypertension, dyslipidaemia) after stroke. Although living arrangements were not analysed in this study, the findings support the importance of providing adequate social support after discharge to ensure access to appropriate follow-up care, which includes vaccination, oral hygiene, catheter care and chronic disease management, as mentioned previously.

Independent risk factors for readmission reported in this study were: older age, presence of co-morbidities, presence of inpatient medical complications during initial hospitalization and functional status, which are commonly reported variables associated with higher readmission rates in systemic reviews (1, 3, 5). Pre-existing medical conditions and increased frailty in stroke survivors have been known to be associated with medical complications (25, 26). Frailty, a common geriatric syndrome, is marked by increased vulnerability and decreased physical and cognitive reserves, and has been a consistent predictor for multiple adverse health outcomes, including poorer functional outcomes, falls and delirium, which may also explain higher readmission rates (27). In a study by Gregersen et al., for example, geriatric patients who were defined as frail on the Multidimensional Prognostic Index, which includes elements such as activities of daily living, cognitive status and severity of morbidity, were found to have a higher hazard ratio for unplanned readmission within 30 days compared with non-frail individuals (28). Thorough pre-discharge home assessment and continued post-discharge rehabilitation may be useful to improve physical function and ensure home safety in frail patients, and thus may reduce falls, which are a significant contributor to readmissions (29, 30).

A high prevalence of inpatient complications was observed in this study, with infectious aetiologies, psychiatric aetiologies and stroke progression being major causes. Further research is required to investigate the causal effect of these complications on readmission rates, whether inpatient interventions help to reduce the frequency of certain complications, and the extent to which complications can be prevented. These risk factors may also help clinicians to identify patients who warrant greater surveillance and community support after discharge.

Poorer functional status on admission also contributes to a higher readmission risk in stroke survivors, while a RLOS and functional gain were associated with reduced readmission risk. Previous studies have demonstrated reduced post-stroke complications with improved functional outcome at discharge (31), and it is likely that increased functional gain, and therefore improved functional outcome on discharge, reduces readmission risk even at one year and beyond, based on the findings of the current study. Other studies have also shown that functional status is minimally confounded by demographic factors (32, 33). This supports the view that interventions, including intensive therapy, to improve functional status or mobility can potentially be associated with lower readmission rates in the post-acute setting (34, 35). Hence, the current study adds to the existing literature by demonstrating that the functional improvement during inpatient rehabilitation is associated with a lower readmission rate even at 1–3 years post-stroke.

This study has several limitations. To affirm the causality of the risk factors, a longitudinal study is required. In particular, the role of hospital-level practices, the effect on patient-level variables and the pathway that defines rehabilitation and outcomes, needs to be better elucidated. Some patients may have been readmitted to a hospital outside the regional group, although a local study found less than 6% incidence of this event occurring (36). It was not possible to capture all non-clinical variables which may be potential covariates (e.g. family support systems, socioeconomic status) as these were not available. As this is a single-centre study, the generalizability of the findings may be limited, although it is notable that several of the results have been replicated in non-Asian multi-centre studies (3). Lastly, although ischaemic stroke occurs more frequently than haemorrhagic stroke (37), the current study had an approximately equal proportion of patients with haemorrhagic and ischaemic stroke.

In conclusion, this study highlights the high readmission rates in stroke survivors even after the first year post-stroke. Some readmissions could potentially be addressed through fall risk assessments, vaccinations, meticulous nursing and preventive care. Further research into these associations and the relevant interventions during and after discharge, such as appropriate and intensive rehabilitation, individualized patient education, transitional care resources, discharge planning, physician follow-up, aggressive management of cardiovascular risk factors and continued

post-discharge rehabilitation, are warranted to reduce readmission rates and the resultant healthcare burden.

REFERENCES

1. Zhong W, Geng N, Wang P, Li Z, Cao L. Prevalence, causes and risk factors of hospital readmissions after acute stroke and transient ischemic attack: a systematic review and meta-analysis. Neurol Sci 2016; 37: 1195–1202.
2. Ottenbacher KJ, Karmarkar A, Graham JE, Kuo YF, Deutsch A, Reistetter TA, et al. Thirty-day hospital readmission following discharge from postacute rehabilitation in fee-for-service Medicare patients. JAMA 2014; 311: 604–614.
3. Lichtman JH, Leifheit-Limson EC, Jones SB, Watanabe E, Bernheim SM, Phipps MS, et al. Predictors of hospital readmission after stroke: a systematic review. Stroke 2010; 41: 2525–2533.
4. Otokita S, Uematsu H, Kunisawa S, Sasaki N, Fushimi K, Imanaka Y. Impact of rehabilitation start time on functional outcomes after stroke. J Rehabil Med 2021 13; 53: jrm00145.
5. Rao A, Barrow E, Vuik S, Darzi A, Aylin P. Systematic review of hospital readmissions in stroke patients. Stroke Res Treat 2016; 2016: 9325368.
6. Chang KC, Hung JW, Lee HC, Yen CL, Wu CY, Yang CL, et al. Rehabilitation reduced readmission and mortality risks in patients with stroke or transient ischemic attack: a population-based study. Med Care 2018; 56: 290–298.
7. Andrews AW, Li D, Freburger JK. Association of rehabilitation intensity for stroke and risk of hospital readmission. Phys Ther 2015; 95: 1660–1667.
8. van Walraven C, Austin P. Administrative database research has unique characteristics that can risk biased results. J Clin Epidemiol 2012; 65: 126–131.
9. Sacco RL, Kasner SE, Broderick JP, Caplan LR, Connors JJ, Culebras A, et al. An updated definition of stroke for the 21st century: a statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2013; 44: 2064–2089.
10. Heinemann AW, Linacre JM, Wright BD, Granger CV. Relationships between impairment and physical disability as measured by the Functional Independence Measure. Arch Phys Med Rehabil 1993; 74: 566–573.
11. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987; 40: 373–383.
12. Quan H, Li B, Couris CM, Fushimi K, Graham P, Hider P, et al. Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. Am J Epidemiol 2011; 173: 676–682.
13. Charlson M, Wells MT, Ullman R, King F, Shmukler C. The Charlson Comorbidity Index can be used prospectively to identify patients who will incur high future costs. PLoS One 2014; 9: e112479.
14. Itaya T, Murakami Y, Ota A, Nomura E, Fukushima T, Nishigaki M. Assessment model to identify patients with stroke with a high possibility of discharge to home: a retrospective cohort study. Stroke 2017; 48: 2812–2818.
15. Tanwir S, Montgomery K, Chari V, Nesathurai S. Stroke rehabilitation: availability of a family member as caregiver and discharge destination. Eur J Phys Rehabil Med 2014; 50: 355–362.
16. Hoyer EH, Needham DM, Atanelov L, Knox B, Friedman M, Brotman DJ. Association of impaired functional status at hospital discharge and subsequent rehospitalization. J Hosp Med 2014; 9: 277–282.
17. Lim JY, Jung SH, Kim WS, Paik NJ. Incidence and risk factors of poststroke falls after discharge from inpatient rehabilitation. PM R 2012; 4: 945–953.
18. Ng MM, Hill KD, Batchelor F, Burton E. Factors predicting falls and mobility outcomes in patients with stroke returning home after rehabilitation who are at risk of falling. Arch Phys Med Rehabil 2017; 98: 2433–2441.
19. Baetens T, De Kegel A, Calders P, Vanderstraeten G, Cambier D. Prediction of falling among stroke patients in rehabilitation. J Rehabil Med 2011; 43: 876–883.
20. Burke JF, Skolarus LE, Adelman EE, Reeves MJ, Brown DL. Influence of hospital-level practices on readmission after ischemic stroke. Neurology 2014; 82: 2196–2204. Erratum in: Neurology 2015; 84: 330.
21. Domínguez À, Soldevila N, Toledo D, Torner N, Force L, Pérez MJ, et al. Effectiveness of 23-valent pneumococcal polysaccharide vaccination in preventing community-acquired pneumonia hospitalization and severe outcomes in the elderly in Spain. PLoS One 2017; 12: e0171943.
22. Warren C, Medei MK, Wood B, Schutte D. A nurse-driven oral care protocol to reduce hospital-acquired pneumonia. Am J Nurs 2019; 119: 44–51.
23. Net P, Karnycheff F, Vasse M, Bourdain F, Bonan B, Lapergue B. Urinary tract infection after acute stroke: impact of indwelling urinary catheterization and assessment of catheter-use practices in French stroke centers. Rev Neurol (Paris) 2018; 174: 145–149.
24. Bjerkreim AT, Naess H, Khanevski AN, Thomassen L, Waje-Andreassen U, Logallo N. One-year versus five-year hospital readmission after ischemic stroke and TIA. BMC Neurol 2019; 19: 15.
25. Chen CM, Hsu HC, Chang CH, Lin CH, Chen KH, Hsieh WC, et al. Age-based prediction of incidence of complications during inpatient stroke rehabilitation: a retrospective longitudinal cohort study. BMC Geriatr 2014; 14: 41.
26. Kitisomprayoonkul W, Sungkapo P, Taveemanoon S, Chaiwanichsiri D. Medical complications during inpatient stroke rehabilitation in Thailand: a prospective study. J Med Assoc Thai 2010; 93: 594–600.
27. Hao Q, Zhou L, Dong B, Yang M, Dong B, Weil Y. The role of frailty in predicting mortality and readmission in older adults in acute care wards: a prospective study. Sci Rep 2019; 9: 1207.
28. Gregersen M, Hansen TK, Jørgensen BB, Damsgaard EM. Frailty is associated with hospital readmission in geriatric patients: a prognostic study. Eur Geriatr Med 2020; 11: 783–792.
29. Inokuchi S, Matsusaka N, Hayashi T, Shindo H. Feasibility and effectiveness of a nurse-led community exercise programme for prevention of falls among frail elderly people: a multicentre controlled trial. J Rehabil Med 2007; 39: 479–485.
30. Lockwood KJ, Taylor NF, Harding KE. Pre-discharge home assessment visits in assisting patients' return to community living: a systematic review and meta-analysis. J Rehabil Med 2015; 47: 289–299.
31. Janus-Laszuk B, Mirowska-Guzel D, Sarzynska-Dlugosz I, Czlonkowska A. Effect of medical complications on the after-stroke rehabilitation outcome. NeuroRehabilitation 2017; 40: 223–232.
32. Chung DM, Niewczyk P, DiVita M, Markello S, Granger C. Predictors of discharge to acute care after inpatient rehabilitation in severely affected stroke patients. Am J Phys Med Rehabil 2012; 91: 387–392.
33. Ottenbacher KJ, Graham JE, Ottenbacher AJ, Lee J, Al Snih S, Karmarkar A, et al. Hospital readmission in persons with stroke following postacute inpatient rehabilitation. J Gerontol A Biol Sci Med Sci 2012; 67: 875–881.
34. Slocum C, Gerrard P, Black-Schaffer R, Goldstein R, Singhal A, DiVita MA, et al. Functional status predicts acute care readmissions from inpatient rehabilitation in the stroke population. PLoS One 2015; 10: e0142180.
35. Shih SL, Zafonte R, Bates DW, Gerrard P, Goldstein R, Mix J, et al. Functional status outperforms comorbidities as a predictor of 30-day acute care readmissions in the inpatient rehabilitation population. J Am Med Dir Assoc 2016; 17: 921–926.
36. Sun Y, Lee SH, Heng BH, Chin VS. 5-year survival and rehospitalization due to stroke recurrence among patients with hemorrhagic or ischemic strokes in Singapore. BMC Neurol 2013; 13: 133.
37. Feigin VL, Norrving B, Mensah GA. Global burden of stroke. Circ Res 2017; 120: 439–448.