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

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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. 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.

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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,
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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 severe 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 demographic 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 χ² 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.
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-
significant 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).

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).

**DISCUSSION**

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*, n (%) | 23 (7.8) | 5 (5.7) |
| Neurosurgical*, 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) |

*Causes include giddiness, syncope, headache, Bell’s palsy, neuropathic pain, dystonia and spasticity.

| Odds ratio | 95% CI | p-value |
|------------|-------|---------|
| Age >55 years | 1.48 | 1.05–2.08 | 0.027 |
| Length of acute hospitalization | 1.01 | 0.998–1.01 | 0.153 |
| Rehabilitation length of stay | 0.862 | 0.998–1.01 | 0.428 |
| Admission FIM motor score < 39 | 1.78 | 1.25–2.52 | 0.001 |
| Admission FIM cognition score < 20 | 1.45 | 1.05–2.00 | 0.025 |
| Charlson Comorbidity Index ≥ 1 | 2.88 | 1.86–4.46 | <0.001 |
| Medical complication during initial hospitalization | 2.84 | 2.11–3.83 | <0.001 |
| Discharge destination (Home) | 1.11 | 0.666–1.86 | 0.683 |
| FIM gain of every 10 points during inpatient rehabilitation | 0.814 | 0.747–0.887 | <0.001 |

DISCUSSION

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).
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.

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