Factors Associated With 90-Day Readmission After Stroke or Transient Ischemic Attack

Linked Data From the Australian Stroke Clinical Registry

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Background and Purpose—Readmissions after stroke are common and appear to be associated with comorbidities or disability-related characteristics. In this study, we aimed to determine the patient and health-system level factors associated with all-cause and unplanned hospital readmission within 90 days after acute stroke or transient ischemic attack (TIA) in Australia.

Methods—We used person-level linkages between data from the Australian Stroke Clinical Registry (2009–2013), hospital admissions data and national death registrations from 4 Australian states. Time to first readmission (all-cause or unplanned) for discharged patients was examined within 30, 90, and 365 days, using competing risks regression to account for deaths postdischarge. Covariates included age, stroke severity (ability to walk on admission), stroke type, admissions before stroke/TIA and the Charlson Comorbidity Index (derived from *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision*, [Australian modified] coded hospital data in the preceding 5 years).

Results—Among the 13 594 patients discharged following stroke/TIA (45% female; 65% ischemic stroke; 11% intracerebral hemorrhage; 4% undetermined stroke; and 20% TIA), 25% had an all-cause readmission and 15% had an unplanned readmission within 90 days. In multivariable analyses, the factors independently associated with a greater risk of unplanned readmission within 90 days were being female (subhazard ratio, 1.13 [95% CI, 1.03–1.24]), greater Charlson Comorbidity Index scores (subhazard ratio, 1.11 [95% CI, 1.09–1.12]) and having an admission ≤90 days before the index event (subhazard ratio, 1.85 [95% CI, 1.59–2.15]). Compared with being discharged to rehabilitation or aged care, those who were discharged directly home were more likely to have an unplanned readmission within 90 days (subhazard ratio, 1.44 [95% CI, 1.33–1.55]). These factors were similar for readmissions within 30 and 365 days.

Conclusions—Apart from comorbidities and patient-level characteristics, readmissions after stroke/TIA were associated with discharge destination. Greater support for transition to home after stroke/TIA may be needed to reduce unplanned readmissions. **(*Stroke*. 2020;51:571-578. DOI: 10.1161/STROKEAHA.119.026133.)**

Key Words: comorbidity ■ health ■ hospitals ■ population ■ rehabilitation

Stroke is a leading cause of disease worldwide, with ≈5.5 million deaths due to stroke each year.[1] Within Australia, almost 50 000 people experience a stroke each year and ≈400 000 people are living with the consequences of stroke.[2] It is estimated that the cost of stroke in Australia exceeds $5.4 billion per annum and is likely to increase with population

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aging.[2] One of the greatest contributors to this cost is hospital care including readmissions. As much as 50% of patients may be readmitted within the first year after their stroke.[3] Commonly reported factors associated with readmissions include older age, recurrent stroke, and greater stroke severity.[3] While it has been shown that variation in clinical care and outcomes between hospitals, regions,[4] and subgroups of patients[5] can lead to ineffective use of health care resources, there are limited data within Australia and elsewhere on health-system factors influencing readmission.[6] In earlier studies in Australia, investigations of readmissions have been limited to readmissions to the same hospital,[7] while readmissions to any hospital have only been completed in a relatively small sample (n=788).[8] Further work is required to ascertain the patient and health-system level factors associated with readmissions at a population level.

The aims of this study were to determine the frequency of, and factors associated with, (1) all-cause and (2) unplanned hospital readmission within the 90 days following hospitalization for acute stroke/transient ischemic attack (TIA; primary outcome). The secondary outcomes were (1) all-cause and (2) unplanned hospital readmission within 30 and 365 days.

Methods

Study Design and Population

This was an observational cohort study of 15 482 patients with stroke/TIA who were registered in the Australian Stroke Clinical Registry (AuSCR) prospectively between 2009 and 2013. The AuSCR is a collaborative national effort to monitor the quality of acute care and outcomes of patients with stroke/TIA admitted to participating hospitals.[9] Hospital clinicians from 39 Australian hospitals, from Victoria, New South Wales, Queensland, and Western Australia, were responsible for identifying eligible cases. Information on the approval processes involved to access data from this study are available from the corresponding author.

Linked Data from Stroke123 Study

Within Australia, hospital funding is provided by State and Territory governments based on the type and mix of cases that are treated (casemix).[10] Each condition or disease is tied to a financial reimbursement for providing patient care and is categorized according to the *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision*, Australian Modification (ICD-10-AM).[11] Since these data are routinely collected against standardized definitions, they can be leveraged to reliably investigate the frequency and cause for readmission to any hospital within Australia.

In 2012, funding was obtained by Cadilhac et al to link AuSCR registrants with hospital admission and emergency presentation data sets as part of the Stroke123 project.[12,13] After initial applications for data linkage in 2013, final data were available for analysis in 2018. The admission data sets include data on all admitted patients from public and private acute and rehabilitation hospitals and includes demographic details (eg, age), administrative data (eg, admission date and discharge date), and clinical data (eg, diagnosis codes of stroke subtype and comorbidities). The emergency presentation data sets comprise details of patients treated at emergency departments at all public hospitals and include demographics (eg, sex), administrative (eg, postcode), and clinical data (eg, diagnosis). In addition, the cohort was linked with the National Death Index to provide accurate mortality information (eg, cause and date of death). The admission data sets were used to determine the frequency and type of readmissions after stroke while the emergency presentation data sets were used solely to determine comorbidities of patients.

Participants Available for Analysis

For the present study, patients were excluded if they (1) were aged <18 years; (2) had died during the first hospital admission registered in the AuSCR (initial index hospitalization). We included patients (1) who were registered in the AuSCR between 2009 and 2013; (2) with all types of stroke (ischemic, intracerebral hemorrhage, and undetermined) and TIA; and (3) registered in the AuSCR who had matched with hospital admission and emergency presentation data sets as part of the Stroke123 project. Data are prospectively collected in the AuSCR. However, in this study the AuSCR was linked to administrative data, which were retrospectively collected, with a restricted set of variables available in the original data sources available for analysis.

Outcomes

The primary outcomes were (1) all-cause hospital readmission and (2) unplanned readmission within 90 days of discharge following hospitalization for acute stroke/TIA. All-cause hospital readmissions were defined as an admission to an acute care hospital for any reason after the index hospitalization. Unplanned readmissions were defined as an admission for any cause to an acute care hospital after the index hospitalization, with the urgency status marked as emergency. The urgency status variable was recorded prospectively at each hospital at the time of admission and was available within the admissions data set.

Episodes of care were created from the date of admission until the date of discharge and incorporated transfers and episode changes. Admissions to rehabilitation directly following the index stroke hospitalization were classified as part of the index hospitalization. The main reason for hospital presentation was obtained from *ICD-10-AM* codes recorded for hospital discharge (principal diagnosis). Secondary outcomes included (1) all-cause and (2) unplanned readmission within 30 and 365 days of discharge.

Patient Factors

Patient characteristics (eg, age and sex), clinical processes of care (eg, admission to an acute stroke unit and use of thrombolysis), stroke severity, and health outcomes (eg, discharge destination and length of stay) were obtained from the AuSCR. Inability to walk on admission was used as a marker for severe stroke as it has been validated as a reliable proxy measure.[14] Comorbidities, such as hypertension and dyslipidemia, were obtained from the *ICD-10-AM* coding within the hospital admissions and emergency department data sets using a look-back period of 5 years before and including the index event.[15] Charlson Comorbidity Index (CCI)[16] scores were calculated for each patient based on the presence of 19 conditions/diseases that each contribute between 1 and 6 points to the overall weighted score. Cerebrovascular events and hemiplegia were excluded from CCI scores due to their increased prevalence in patients with stroke.[17] Socioeconomic position was determined using the index of relative socioeconomic advantage and disadvantage,[18] an area-level indicator based on registrants' postcodes recorded in the AuSCR. Registrants were divided into 5 strata of index of relative socioeconomic advantage and disadvantage, with greater index of relative socioeconomic advantage and disadvantage quintiles indicating lesser relative socioeconomic disadvantage.

Health-System Factors

Clinical processes of care or interventions were collected in the AuSCR and were based on stroke clinical guidelines.[19] Examples include management in a stroke unit, use of thrombolysis in ischemic stroke, provision of care plans at discharge, and provision of medications at discharge. Physical hospital characteristics (such as number of beds, location of hospital, and teaching status) were obtained from individual hospitals participating in the AuSCR. Using hospital admissions data, patients were categorized based on whether they had a recent admission (≤90 days earlier), less recent admission (>90 days earlier), or no admission before the index event.

Statistical Analyses

A log-rank test of significance was used to determine whether differences in survival by stroke type warranted the analyses to be stratified by type of stroke.[20] Descriptive statistics were used to compare patients' characteristics, social circumstances, health system, clinical processes of care, and health outcomes by hospital readmission status. In univariable analyses, χ^2 tests were used for categorical variables and Wilcoxon rank-sum tests for continuous variables.

Multilevel multivariable logistic regression models were used to identify the initial factors associated with readmission within 90 days. As part of this process, variables from the univariable analyses with $P<0.2$ were eligible for inclusion in the models and were excluded if they were either collinear or were no longer significant ($P>0.05$) following the addition of factors with greater statistical significance. In the second stage, factors identified through this process were used to generate multilevel multivariable Cox proportional hazards regression models, enabling assessment of the time to first readmission. These models were adjusted for all variables which were significant in the previous logistic regression model. To account for potential bias due to death from any cause, models were built using competing risk regression to adjust for outcome censoring due to death. We also performed sensitivity analysis including year in our models.

All analyses were performed using STATA/SE 15.0 for Windows (StataCorp, College Station, 2017). Results were presented as subhazard ratios with corresponding 95% CIs. Ethics approval for the Stroke123 project was obtained from the Monash University (CF13/1303–2013000641) and Metro South Health Human Research Ethics Committees. Additional approvals for the linkage of these data were obtained from the AuSCR Research Task Group, the Australian Institute for Health and Welfare, and from Departments of Health in New South Wales, Queensland, Victoria, and Western Australia.

Results

In total, there were 15 482 adults registered in the 4 States in the AuSCR between 2009 and 2013 who were matched to hospital admission and emergency presentation datasets as part of the Stroke123 project. We included all types of stroke and TIA. There were 1874 (12%) deaths during the index admission that were excluded (Figure I in the online-only Data Supplement). Of the 13 594 patients in the sample, 10 797 had a stroke (81% ischemic stroke; 14% intracerebral hemorrhage; 5% undetermined stroke) and 2772 had a TIA. Within 90 days of discharge following the index admission, an additional 839 (6.2%) patients were deceased and 3444 (25.3%) were readmitted. Among the 3444, 90-day readmissions, 2038 (59%) were classified as an unplanned readmission. Based on the primary *ICD-10-AM* code, diseases of the circulatory system were the most common (25.0%) reason for unplanned readmission within 90 days (Figure 1). Of the unplanned readmissions within 90 days of discharge after stroke, 6% were due to falls and 15% were due to stroke. Of the 486 unplanned readmissions within 90 days of discharge after a TIA, 37 (8%) were due to stroke. Since we could not detect a significant difference in 90-day readmissions by type of stroke (Figure I in the online-only Data Supplement), patients with TIA and stroke were combined as a heterogenous cohort for subsequent analyses.

In univariable results, basic demographics (age, sex, and country of birth) were similar between patients with and without an all-cause readmission (Table 1). However, unplanned readmissions were more common in females and in older patients. In both all-cause and unplanned readmissions, patients with a documented history of stroke before the index event were more frequently readmitted than those without previous stroke. Readmitted patients were more likely to have risk factors for stroke such as diabetes mellitus, and more likely to have comorbidities such as cancer, heart failure, and renal disease. Importantly, patients with a CCI score of ≥3

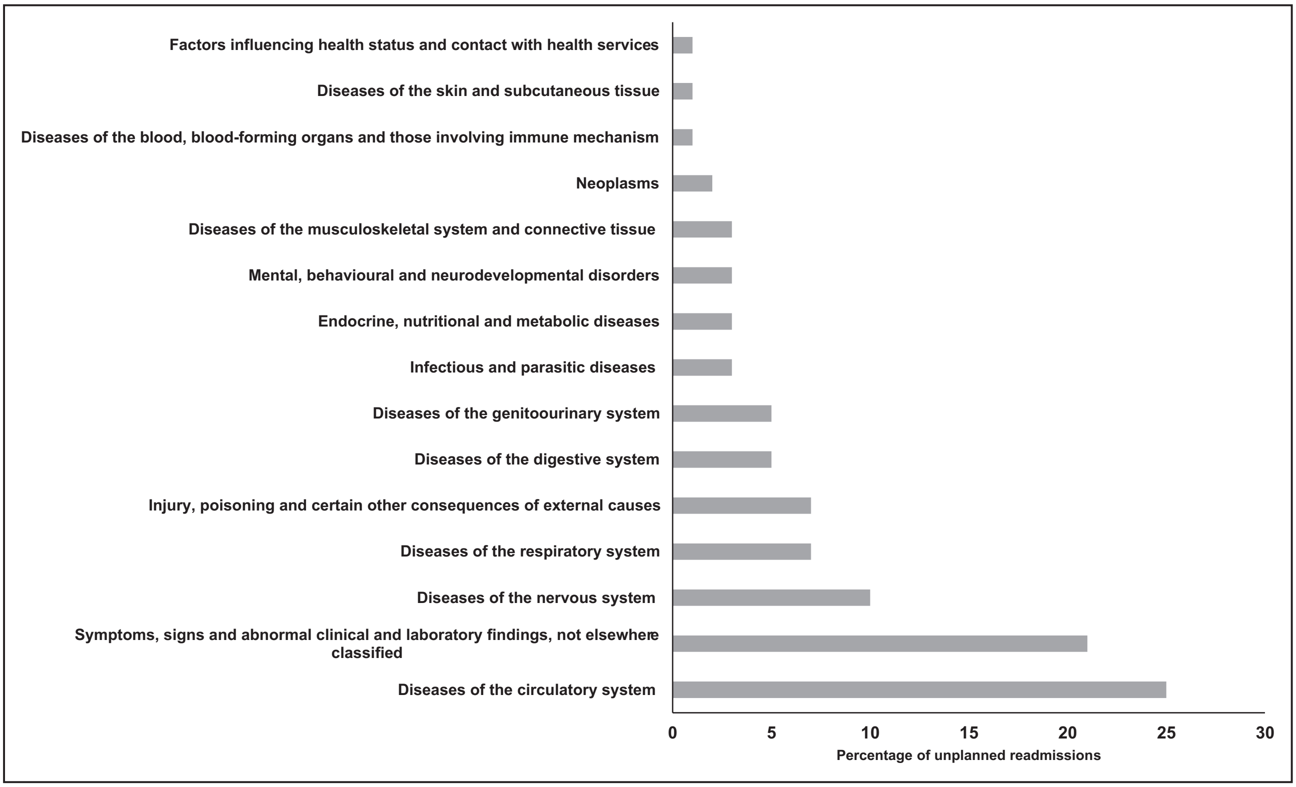

Figure 1. Principal diagnosis of first unplanned readmission within 90 d.

were more likely to have an unplanned and all-cause readmission compared with patients with a CCI score of 1 or 2 (P<0.001).

Patients who were treated in a metropolitan hospital or in a hospital with >300 beds were more likely to experience an all-cause readmission within 90 days than those admitted to a rural hospital or hospital with fewer beds (Table 2). There were no differences between clinical processes of care between those with and without an all-cause hospital readmission. Compared with being discharged to rehabilitation, aged care or other hospital care, patients who were discharged directly home were more likely to be readmitted within 90 days for an all-cause or unplanned readmission (Table 2, Figure II in the online-only Data Supplement).

In our adjusted models, we found women were 13% more likely to have an unplanned readmission within 90 days compared with men (Table 3). Other patient factors associated with unplanned readmission included older age, patients with TIA, and history of prior stroke. Patients with admission to hospital ≤90 days before their index hospitalization were 85% more likely to have an unplanned readmission than patients with no prior admission (Table 3, Figure 2). Patients with a greater CCI score were more likely to experience an all-cause hospital or unplanned readmission within 90 days, independent of other factors, such as age, sex, stroke severity, type of stroke, and discharge destination (Table 3, Figure III in the online-only Data Supplement). Similar factors were also associated with hospital readmission within 30 days and within 365 days (Tables I and II in the online-only Data Supplement). Sensitivity analysis including year in our models did not change our results.

Discussion

Given the growing burden of stroke on health systems, this research has provided important information for clinicians, health administrators, and policy makers on the characteristics of patients who experience hospital readmission after stroke. In our study, we found hospital readmission within 90 days to be frequent after stroke, with 15% of the cohort experiencing an unplanned readmission and 25% experiencing an all-cause readmission. These estimates are comparable to earlier studies performed in the United States which report all-cause hospital readmission to occur in 15% to 20% of patients with stroke.[21,22] Importantly, the current study provides the most comprehensive analysis of factors associated with both all-cause and unplanned readmission during the first 90 days after acute stroke/TIA within Australia or elsewhere.[3,7] These data will be important for facilitating the refinement and implementation of strategies aimed at preventing readmission after stroke.

The findings from the present study validate the results of our earlier pilot study (n=788) using data from one AuSCR hospital linked with administrative data from a single state.[8] In this earlier pilot study, we identified many patient-level factors associated with readmission within 1-year poststroke. Factors included 2 or more presentations to an emergency department before the event (adjusted odds ratio, 1.57 [95% CI, 1.02–2.43]) and greater CCI scores (adjusted odds ratio, 1.19 [95% CI, 1.07–1.32]). In the current study, we were able to substantiate these results in a larger and more diverse cohort using cross-jurisdictional linked data from 4 states. These patient factors were also associated with readmission within 30 and 365 days and indicate that interventions targeting patients with these factors may help to reduce readmissions at a population level.

A significant finding from this study was that readmissions were predominantly related to patient-level factors rather than clinical processes of care. This is consistent with data from other conditions where clinical processes of care had only very weak, or no relationship to the risk of readmission.[23] Therefore, prevention of readmission may require greater individualization of interventions focused during the postdischarge period. The much lower proportion of readmissions in patients receiving inpatient rehabilitation suggests that attention to clinical processes of care central to rehabilitation, such as patient centered goal setting, and improvement in function, may be an appropriate starting point.

In this study, we found that patients who were discharged directly home (compared with transfer for inpatient rehabilitation, or other care including residential aged care) were at greater risk of 90-day readmission. These findings coincide with an earlier study performed in the United States[24] and highlight the poor outcomes of survivors of stroke/TIA who are discharged directly home. There is evidence to indicate that patients who are discharged directly home have limited access to information, health and community support services, which may contribute to undesirable patient outcomes such as hospital readmission.[25] However, it was interesting that receiving a care plan at discharge was not associated with outcomes in our study given that there is evidence that discharge planning may reduce the risk of readmission.[26] Discharge care planning after stroke in Australian hospitals may vary in quality and there may be bias in patients who are provided discharge care planning. Establishing better transitions of care for those being discharged home after stroke in Australia may be necessary. Therefore, interventions aimed at improving postdischarge support for patients discharged directly home may also help to prevent readmissions. We are currently developing and testing a new discharge support package for survivors of stroke through the use of individualized electronic health messages[27] linked to self-selected recovery goals as part of the ReCAPS trial (Recovery-Focussed Community Support to Avoid Readmissions and Improve Participation After Stroke). Data generated from this trial will help to inform whether improved postdischarge support can reduce readmissions in patients discharged directly home after stroke.

We found women were 13% more likely to have an unplanned hospital readmission within 90 days than men. This finding is similar to an earlier observational study performed in 4850 US patients with ischemic stroke who received mechanical thrombectomy.[21] In this study, the authors reported women were 34% (95% CI, 2%–77%) more likely to experience an unplanned readmission within 30 days of discharge than men. This association may be partially explained by the fact that women tend to experience more severe and rarer forms of stroke than men and are less likely to achieve

Table 1. Comparison of Patient Characteristics by Hospital Readmission Within 90 Days

	All-Cause Readmission			Unplanned Readmission		
	Yes, N=3444	No, N=10 150		Yes, N=2038	No, N=11 556	
	n (%)	n (%)	*P* Value	n (%)	n (%)	*P* Value
Patient characteristics						
Female	1548 (45.0)	4628 (45.6)	0.54	985 (48.5)	5191 (45.0)	0.003
Median age, y (Q1–Q3)	75.3 (64.1–83.1)	74.7 (64.2–83.2)	0.89	78.0 (68.3–84.7)	74.2 (63.6–82.8)	<0.001
Born in Australia	2244 (65.2)	6589 (64.9)	0.80	1305 (64.0)	7528 (65.1)	0.33
Documented evidence of previous stroke*	728 (22.5)	1918 (20.1)	0.004	489 (25.6)	2157 (19.8)	<0.001
Socioeconomic position†			0.001			0.51
Most disadvantaged	566 (16.4)	1930 (19.0)		380 (18.7)	2166 (18.3)	
Second most disadvantaged	565 (16.4)	1792 (17.7)		364 (17.9)	1993 (17.3)	
Third most disadvantaged	562 (16.3)	1640 (16.2)		340 (16.7)	1862 (16.1)	
Fourth most disadvantaged	685 (19.9)	1885 (18.6)		393 (19.3)	2177 (18.8)	
Least disadvantaged	1066 (31.0)	2903 (28.6)		561 (27.5)	3408 (29.5)	
Stroke severity						
Unable to walk on admission‡	1563 (51.1)	4950 (54.1)	0.004	990 (54.7)	5523 (53.1)	0.21
Type of stroke			0.033			<0.001
Intracerebral hemorrhage	360 (10.5)	1141 (11.3)		215 (10.6)	1286 (11.2)	
Ischemic stroke	2185 (63.6)	6608 (65.2)		1228 (60.4)	7565 (65.6)	
Transient ischemic attack	757 (22.0)	2015 (19.9)		490 (24.1)	2282 (19.8)	
Undetermined	134 (3.9)	369 (3.6)		99 (4.9)	404 (3.5)	
Comorbidities						
Atrial fibrillation	1098 (31.9)	2974 (29.3)	0.004	741 (36.4)	3331 (28.8)	<0.001
Hypercholesterolemia	682 (19.8)	1594 (15.7)	<0.001	409 (20.1)	1867 (16.2)	<0.001
Hypertension	2441 (70.9)	7021 (69.2)	0.06	1499 (73.6)	7963 (68.9)	<0.001
Diabetes mellitus	747 (21.7)	1852 (18.3)	<0.001	411 (20.2)	1642 (14.2)	<0.001
Angina	785 (22.8)	1682 (16.6)	<0.001	510 (25.0)	1957 (16.9)	<0.001
Smoking (current)	746 (21.7)	2147 (21.2)	0.53	446 (21.9)	2447 (21.2)	0.47
Obesity	224 (6.5)	428 (4.2)	<0.001	132 (6.5)	520 (4.5)	<0.001
Peripheral vascular disease	185 (5.4)	394 (3.9)	0.001	105 (5.2)	474 (4.1)	0.03
Congestive heart failure	531 (15.4)	1075 (10.6)	0.001	387 (19.0)	1219 (10.6)	<0.001
Myocardial infarction	493 (14.3)	1094 (10.8)	<0.001	344 (16.9)	1243 (10.8)	<0.001
Renal disease	544 (15.8)	1015 (10.0)	<0.001	374 (19.3)	1185 (10.3)	<0.001
Dementia	226 (6.6)	691 (6.8)	0.62	186 (9.1)	731 (6.3)	<0.001
Cancer	505 (14.7)	925 (9.1)	<0.001	302 (14.8)	1128 (9.8)	<0.001
Charlson Comorbidity Index			<0.001			<0.001
0	1468 (42.6)	5280 (52.0)		727 (35.7)	6021 (52.1)	
1	558 (16.2)	1855 (18.3)		371 (18.2)	2042 (17.7)	
2	477 (13.9)	1147 (11.3)		298 (14.6)	1326 (11.5)	
3+	941 (27.3)	1868 (18.4)		642 (31.5)	2167 (18.8)	

Q1 denotes 25th percentile, and Q3 denotes 75th percentile.
†Measured by Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD).
*5%–9% missing/not documented data.
‡10%–15% missing/not documented data.

Table 2. Comparison of Health System, Clinical Care, and Discharge Destination by Hospital Readmission Within 90 Days

	All-Cause Readmission Within 90 D			Unplanned Readmission Within 90 D		
	Yes, N=3444	No, N=10 150		Yes, N=2038	No, N=11 556	
	n (%)	n (%)	*P* Value	n (%)	n (%)	*P* Value
Health-system factors						
Median length of stay (Q1–Q3), d	5 (2–9.5)	5 (3–9)	0.50	5 (2–9)	5 (2–9)	0.94
Transfer from another hospital	378 (11.1)	1339 (13.4)	0.001	196 (9.8)	1521 (13.3)	<0.001
Stroke occurred while in hospital	155 (4.6)	419 (4.2)	0.34	86 (4.3)	488 (4.3)	0.97
Treated in a teaching hospital	1600 (46.5)	4552 (44.9)	0.10	949 (46.6)	5203 (45.0)	0.20
Treated in a metropolitan hospital	2851 (82.8)	8030 (79.1)	<0.001	400 (19.6)	2313 (20.0)	0.69
Treated in a hospital with >300 beds	2768 (80.4)	7911 (77.9)	0.003	1594 (78.2)	9085 (78.6)	0.68
Hospital admission before index event			0.001			<0.001
No prior admission	468 (13.6)	1963 (19.3)		195 (9.6)	2236 (19.4)	
Admission ≤90 days before index event	255 (7.4)	545 (5.4)		152 (7.5)	648 (5.6)	
Admission >90 days before index event	2721 (79.0)	7642 (75.3)		1691 (83.0)	8672 (75.0)	
Clinical processes of care*						
Treated in a stroke unit	2685 (78.0)	7998 (78.8)	0.30	1549 (76.1)	9134 (79.0)	0.002
Received thrombolysis	220 (10.2)	734 (11.2)	0.17	121 (10.0)	833 (11.1)	0.24
Discharged with an antihypertensive agent	2368 (68.8)	6865 (67.6)	0.22	1432 (72.0)	7801 (69.1)	0.010
Received a care plan at discharge if discharged to the community†	1037 (48.2)	2641 (46.5)	0.18	610 (50.7)	3068 (50.7)	0.97
Discharge destination						
Discharged directly home	1946 (56.5)	5047 (49.7)	<0.001	1135 (55.7)	5858 (50.7)	<0.001
Discharged to aged care facility	207 (6.0)	638 (6.3)	0.56	171 (8.4)	674 (5.8)	<0.001
Discharged to inpatient rehabilitation facility	838 (24.3)	2908 (28.7)	<0.001	465 (22.8)	3281 (28.4)	<0.001

Q1 denotes 25th percentile and Q3 denotes 75th percentile.
*Recorded in the Australian Stroke Clinical Registry in all participating hospitals based on the national minimum dataset for evidence-based care provision.
†5%–10% missing data.

independence in activities of the daily living within 3 months of discharge.[28] Furthermore, there is also evidence that female survivors of stroke are more likely to be disabled, single, or require assisted living than men 3 to 6 months after stroke.[29] Together, these findings highlight the poor outcomes of women poststroke and the need for improved support in the community to improve recovery after stroke and prevent readmissions.

A major strength of our study was the use of registry data from the AuSCR linked with hospital administrative data from 4 states within Australia. This comprehensive data set enabled us to assess the risk of 90-day readmissions to any hospital, and the factors associated with all-cause and unplanned readmission from a large number of hospitals contributing to the AuSCR. This is a major advance on our prior work in Australia where assessment of readmissions was limited to the same hospital or multiple hospitals within a single state.[7,8] The use of registry data also enabled the investigation of a wider range of factors relating to acute stroke care and patient outcomes that are not routinely collected in hospital administrative data. Another strength of our study was the use of multilevel modeling in the analyses to account for any potential differences in readmissions rates, as well as other differences including coding conventions and policies between hospitals related to local differences in policy and practice. To account for potential differences in the policy over time, in sensitivity analyses we included the year in our models and the results were similar.

A limitation was that we were unable to determine whether readmissions were potentially preventable with improved in-hospital care. Further work is needed to characterize whether certain *ICD-10-AM* codes represent a readmission that can be prevented through improved clinical processes of care or hospital systems. Moreover, since our study design was observational and included the use of retrospective linked administrative data, caution must be taken when generalizing findings as there may be unmeasured sources of confounding. Another limitation is that the cohort of patients was admitted for stroke between 2009 and 2013. Since this time, there have been changes to clinical guidelines in Australia, particular to the provision of acute services after the introduction of endovascular clot retrieval. However, these results remain novel since this is the first time reliable data on 90-day readmissions after stroke/TIA have been described in Australia or elsewhere.

Table 3. Multivariable Analysis of Factors Associated With 90-Day All-Cause and Unplanned Hospital Readmission

Readmission Within 90 D	All-Cause Readmission* N=13 227		Unplanned Readmission* N=13 236	
No. of patients readmitted	3309 (25%)		1940 (15%)	
No. of competing events (deaths)	667 (5%)		683 (5%)	
	SHR (95% CI)	*P* value	SHR (95% CI)	*P* value
Patient factors				
Age (per y increase)	1.00 (0.99–1.00)	0.08	1.01 (1.01–1.01)	<0.001
Female	1.02 (0.96–1.09)	0.44	1.13 (1.03–1.24)	0.010
Unable to walk on admission	0.95 (0.86–1.06)	0.40	1.09 (0.98–1.22)	0.12
History of stroke before index event	1.06 (0.94–1.19)	0.36	1.17 (1.02–1.34)	0.022
Type of stroke†				
Ischemic stroke	0.97 (0.86–1.10)	0.63	0.91 (0.76–1.08)	0.26
TIA	0.99 (0.83–1.18)	0.90	1.09 (0.91–1.32)	0.35
Undetermined stroke	1.07 (0.90–1.27)	0.46	1.20 (1.00–1.44)	0.049
Charlson Comorbidity Index	1.10 (1.08–1.11)	<0.001	1.11 (1.09–1.12)	<0.001
Health-system factors				
Management in a stroke unit	1.02 (0.91–1.13)	0.78	0.97 (0.88–1.06)	0.47
Length of stay >20 d	0.87 (0.73–1.03)	0.10	0.94 (0.75–1.17)	0.58
Discharged to home	1.35 (1.21–1.51)	<0.001	1.44 (1.33–1.55)	<0.001
Admission before stroke‡				
Within 90 d	1.58 (1.31–1.91)	<0.001	1.85 (1.59–2.15)	<0.001
Greater than 90 d	1.28 (1.15–1.43)	<0.001	1.60 (1.34–1.92)	<0.001

SHR indicates subdistribution hazard ratio; and TIA, transient ischemic attack.
*Each model adjusted for all variables shown plus socioeconomic position and in-hospital stroke.
†Intracerebral hemorrhage used as reference category.
‡No admission before stroke used as reference category.

Conclusions

In summary, we have provided novel findings of the importance of individual factors associated with hospital readmission within 90 days after stroke/TIA in Australia. This information will assist in targeting future interventions that may reduce readmissions. In addition, closer follow-up of patients with stroke/TIA in the community may be needed to prevent readmissions among patients discharged directly home after stroke.

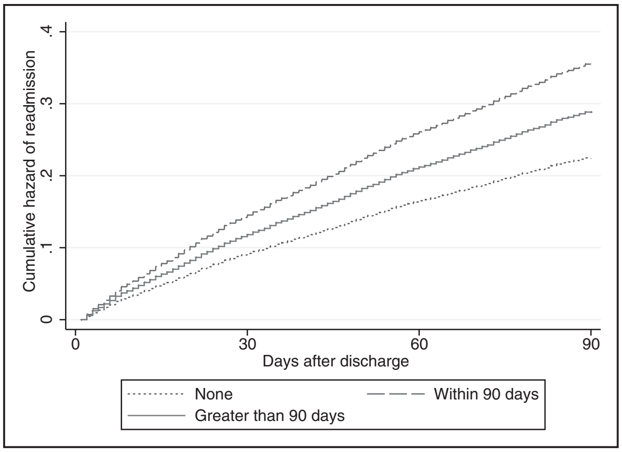

Figure 2. Cumulative subhazard of readmission within 90 days by admissions before the index stroke/transient ischemic attack (TIA; no prior admission for stroke, vs previous admission within 90 days before index stroke/TIA and greater than 90 days before index stroke/TIA).

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Disclosures

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