

## **Is length of time in a stroke unit associated with better outcomes for patients with stroke in Australia? An observational study**

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**Supplemental Table A. Characteristics of patients with stroke treated in a stroke unit versus those not treated in a stroke unit**

<b>Treated in a stroke unit</b>	<b>Yes (N= 2739) n (%)</b>	<b>No (N=684) n (%)</b>	<b>p-value</b>
<b>Patient characteristics</b>			
Age, median (Q1, Q3)	76 (65, 84)	77 (65, 86)	<b>0.03</b>
Male	1530 (56)	347 (51)	<b>0.02</b>
Living at home prior to stroke	2522 (92)	586 (86)	<b>&lt;0.001</b>
Independent prior to stroke (mRS 0–2)	2280 (83)	496 (73)	<b>&lt;0.001</b>
In hospital stroke	75 (3)	54 (8)	<b>&lt;0.001</b>
<b>Stroke type</b>			
Ischaemic stroke	2302 (84)	449 (66)	<b>&lt;0.001</b>
Haemorrhagic stroke	286 (10)	163 (24)	<b>&lt;0.001</b>
Unknown stroke type	151 (6)	72 (11)	<b>&lt;0.001</b>
<b>Stroke severity</b>			
Arm weakness on admission	1675 (62)	352 (59)	0.18
Impaired speech on admission	1582 (59)	333 (57)	0.43
Unable to walk on admission	1454 (54)	392 (59)	<b>0.02</b>
Incontinence at 72 hours of admission	857 (32)	258 (42)	<b>&lt;0.001</b>
<b>History of comorbidities</b>			
Atrial fibrillation			
Hypercholesterolemia	1058 (44)	225 (43)	0.73
Hypertension	1820 (70)	419 (70)	0.92
Diabetes mellitus	669 (27)	160 (29)	0.36
Ischaemic heart disease	670 (28)	175 (33)	<b>0.02</b>
Previous stroke or TIA	814 (33)	221 (39)	<b>0.007</b>
<b>Organisational characteristics</b>			
Metropolitan hospital	2672 (98)	661 (97)	0.18
Private hospital	217 (8)	37 (5)	<b>0.03</b>
Stroke care coordinator present	1626 (59)	446 (65)	<b>0.005</b>
Access to onsite neurosurgery	1000 (37)	210 (31)	<b>0.004</b>
Dedicated multi-disciplinary team present	2706 (99)	677 (99)	0.69
ED protocols for rapid triage	2625 (96)	643 (94)	<b>0.04</b>
Access to on site MRI within 24 hours	2136 (78)	517 (76)	0.18
Stroke team involved in quality improvement in last 2 years	2416 (88)	543 (79)	<b>&lt;0.001</b>
Clinical care pathways for managing stroke present	2339 (85)	569 (83)	0.15
Access to early supported discharge team	338 (12)	103 (15)	0.06
Patients given discharge care plan	1275 (47)	347 (51)	0.05
Regular multi-disciplinary team meetings	2683 (98)	665 (97)	0.24
Arrangements with ambulance for rapid transfers	1897 (73)	498 (78)	<b>0.003</b>

<b>Treated in a stroke unit</b>	<b>Yes (N= 2739) n (%)</b>	<b>No (N=684) n (%)</b>	<b>p-value</b>
Offering thrombolysis	2404 (88)	606 (89)	0.55
Program for continuing education of staff	2609 (95)	649 (95)	0.69
Number of beds on SU			<b>&lt;0.001</b>
<5	1246 (45)	380 (56)	
5-9	790 (29)	179 (26)	
≥10	703 (26)	125 (18)	
Stroke admissions last year ≥100	2558 (93)	602 (88)	<b>&lt;0.001</b>
CT scanning within 3 hours for all patients	2690 (98)	676 (99)	0.26
<b>Clinical processes of care</b>			
Brain scan within 24 hrs of ED arrival	2108 (96)	496 (96)	0.35
Assessment in the ED	1071 (44)	127 (28)	<b>&lt;0.001</b>
Time-critical therapy			
Thrombolysis in ischaemic stroke (with exclusions)	198 (10)	24 (6)	<b>0.01</b>
Assessment for rehabilitation by a physiotherapist within 24-48 hours of hospital admission	1605 (59)	198 (29)	<b>&lt;0.001</b>
Rehabilitation therapy within 48 hours of initial assessment	1899 (89)	249 (67)	<b>&lt;0.001</b>
Transition from hospital care			
Written care plan	1113 (61)	192 (48)	<b>&lt;0.001</b>
<b>Outcomes</b>			
Any severe complication <sup>a</sup>	277 (10)	135 (20)	<b>&lt;0.001</b>
Independent on discharge (mRS 0-2)	1285 (51)	263 (51)	0.84
Died in hospital	207 (8)	170 (25)	<b>&lt;0.001</b>
Discharge destination (survivors)			
Private residence	1350 (53)	293 (57)	0.13
Residential aged care facility	156 (6)	43 (8)	0.07
Inpatient rehabilitation	785 (31)	77 (15)	<b>&lt;0.001</b>
Other hospital ward	191 (8)	90 (18)	<b>&lt;0.001</b>
<b>In-hospital complications</b>			
Aspiration Pneumonia	183 (7)	45 (7)	0.92
Falls	167 (6)	26 (4)	<b>0.02</b>
Fever	289 (11)	75 (11)	0.75
Urinary tract infections	169 (6)	30 (4)	0.07
New stroke	47 (2)	38 (6)	<b>&lt;0.001</b>
Stroke progression	187 (7)	82 (12)	<b>&lt;0.001</b>
New onset atrial fibrillation	155 (6)	28 (4)	0.10
Symptomatic haemorrhagic transformation	73 (3)	26 (4)	0.11
Deep vein thrombosis	15 (1)	4 (1)	0.91
Seizures	67 (2)	34 (5)	<b>&lt;0.001</b>

Q1: 1st quartile; Q3: 3rd quartile; ED: emergency department; SU: stroke unit; mRS: modified Rankin scale. TIA: transient ischaemic attack; MRI: magnetic resonance imaging; <sup>a</sup>a complication considered incapacitating, life threatening and one that prolongs hospital admission and patient acuity including pneumonia, falls, fever, urinary tract infection, seizures, deep vein thrombosis etc.

**Supplemental Table B. Characteristics of patients with stroke who spent at least 90% and those who spent less than 90% of admission in a stroke unit**

<b>Spent at least 90% of admission in a stroke unit</b>	<b>Yes (N= 1687) n (%)</b>	<b>No (N=968) n (%)</b>	<b>p-value</b>
<b>Patient characteristics</b>			
Living at home prior to stroke	1543 (91)	898 (93)	0.24
Arrived by ambulance <sup>a</sup>	1145 (76)	678 (79)	0.21
History of comorbidities			
Hypercholesterolemia <sup>a</sup>	653 (44)	366 (43)	0.69
Hypertension <sup>b</sup>	1123 (70)	644 (71)	0.76
Diabetes mellitus <sup>c</sup>	401 (26)	253 (29)	0.14
Previous stroke or TIA <sup>c</sup>	513 (34)	277 (32)	0.49
Clinical processes of care			
Brain scan within 3 hrs of ED arrival <sup>d</sup>	1053 (77)	567 (75)	0.24
<b>Organisational characteristics</b>			
Dedicated multi-disciplinary team present	1669 (99)	953 (98)	0.28
ED protocols for rapid triage	1626 (96)	919 (95)	0.07
Access to on site MRI within 24 hours	1306 (77)	765 (79)	0.33
Clinical care pathways for managing stroke present	1452 (86)	827 (85)	0.65
Patients given discharge care plan	772 (46)	464 (48)	0.28
Arrangements with ambulance for rapid transfers	1163 (73)	675 (73)	0.90
Offering thrombolysis	1490 (88)	838 (87)	0.19
Standardised processes to assess rehabilitation	1346 (80)	749 (77)	0.14
Program for continuing education of staff	1603 (95)	926 (96)	0.46
Neurologist involved in stroke management	1224 (73)	720 (74)	0.31
CT scanning within 3 hours for all patients	1651 (98)	955 (99)	0.15

ED: emergency department; TIA: transient ischaemic attack; CT: computed tomography; <sup>a</sup>11-15% unknown/not documented data; <sup>b</sup>1-5% unknown/not documented data; <sup>c</sup>6-10% unknown/not documented data; <sup>d</sup>16-20% unknown/not documented data.

**Supplemental Table C. Adherence to processes of care for patients who spent at least 90% and those who spent less than 90% of hospital stay in a stroke unit**

Spent at least 90% of hospital stay in a stroke unit	Yes (N= 1687) n (%)	No (N=968) n (%)	p-value
Early assessment			
Assessment in the ED	675 (44)	367 (43)	0.79
Time-critical therapy			
Transport by ambulance to hospital able to provide thrombolysis	1015 (76)	597 (79)	0.23
Thrombolysis in ischaemic stroke (with exclusions) <sup>a</sup>	99 (8)	94 (13)	<b>&lt;0.001</b>
Thrombolysis in ischaemic stroke for those who arrive within 4.5 hours of symptom onset	88 (25)	83 (36)	<b>0.003</b>
Thrombolysis within 60 minutes of hospital arrival	32 (32)	20 (21)	0.08
Time (median) from onset of symptoms to thrombolysis (Q1,Q3)	2.8 (1.9, 3.7)	3 (2.3, 3.8)	0.10
Early rehabilitation			
Assessment for rehabilitation by a physiotherapist within 24-48 hours of hospital admission <sup>b</sup>	1185 (70)	643 (66)	<b>0.04</b>
Rehabilitation therapy within 48 hours of initial assessment	1161 (90)	673 (86)	<b>0.01</b>
Treatment for a rehabilitation goal commencing during an acute hospital admission	1256 (94)	738 (92)	0.14
Minimising risk of another stroke			
Discharge on antihypertensive medication <sup>c</sup>	701 (75)	404 (77)	0.54
Discharge on statin, antihypertensive and antithrombotic medications (ischaemic stroke) <sup>d</sup>	526 (66)	285 (66)	0.84
Discharge on oral anticoagulants for atrial fibrillation (ischaemic stroke)	144 (68)	87 (63)	0.38
Risk factor modification advice before leaving hospital	597 (61)	353 (64)	0.32
Carer training and support			
Carer support needs assessment	113 (64)	79 (72)	0.13
Carer training	99 (55)	58 (56)	0.87
Transition from hospital care			
Written care plan	699 (62)	377 (59)	0.16

ED: emergency department; Q1: 1st quartile; Q3: 3rd quartile; SU: stroke unit; <sup>a</sup> patients with pre-morbid functional impairment, recent surgery, major comorbidity, warfarin with INR>1.7, rapidly improving, imaging showing spontaneous reperfusion, other contraindication; <sup>b</sup> recorded as within 48 hours; <sup>c</sup> excludes those contraindicated to treatment; <sup>d</sup> excludes those where treatment was contraindicated or futile, or the patient refused.

## Supplemental Methods

### Propensity score matching with stratification

Since length of stay (LOS) in a stroke unit can be affected by clinical factors and bed availability, propensity score matching was used to minimise confounding by indication. Group comparisons were made within subgroups of patients with similar propensity scores.

A propensity score indicating the probability of being treated on a stroke unit for  $\geq 90\%$  was generated for each participant based on a multivariable logistic regression model. Clinical characteristic variables that were associated with being treated on a stroke unit for  $\geq 90\%$  in the univariable analysis were included in the multivariable logistic regression model. Being transferred to the stroke unit within 3 hours of arrival to the emergency department was included as a marker for bed availability at the time of admission. Severe complications were also included in the model where relevant since this is a marker for clinical characteristics as well as an outcome.

After the propensity scores were generated, patients were stratified into 5 quintiles of the propensity score. Group comparisons were conducted within the 5 quintiles of the propensity score, and overall with quintiles of the propensity score with the poorest matching of variables included in the multivariable logistic regression model used to generate the propensity score. Multivariable logistic regression was conducted for the analysis of binary outcomes with median regression modelling with bootstrap estimated standard errors for LOS. All analyses were adjusted for the propensity score quintile and clustering by hospital.

### Propensity score generated including severe complications as a variable in the multivariable logistic regression model (Model A)

A propensity score was generated for 734 patients who spent  $<90\%$  of their admission in a stroke unit and 1372 patients who spent  $\geq 90\%$  of their admission in a stroke unit.

<b>Numbers of patients within the quintiles of the propensity score (Model A)</b>		
	<b><math>&lt;90\%</math> time spent in a stroke unit</b>	<b><math>\geq 90\%</math> time spent in a stroke unit</b>
<b>Propensity score quintiles</b>	<b>N</b>	<b>N</b>
1	185	237
2	170	251
3	147	274
4	143	278
5	89	332
Total	734	1372

Several differences in the characteristics of patients were apparent between the treatment groups within the quintiles of the propensity score.

Within quintile 1, there were differences between treatment groups in the proportion of patients who were unable to walk on admission ( $p=0.046$ ) and suffered a severe complication while in hospital ( $p=0.013$ ).

Within quintile 4, there was a difference between treatment groups in the proportion of patients who had a previous history of ischaemic heart disease (p=0.007).

Within quintile 5, there were difference between treatment groups in the proportion of patients who had impaired speech on admission (p=0.021) and were transferred to the stroke unit within 3 hours of arrival to the emergency department (p=0.041).

In quintiles 1, 2 and 3, all patients were not transferred to the stroke unit within 3 hours of arrival to the emergency department. In quintiles 2 and 3, there were no patients who experienced severe complications.

<b>Differences in characteristics between treatment groups within quintiles (Model A)</b>					
	<b>p-values for differences in characteristics between treatment groups within quintiles</b>				
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
Age	0.524	0.366	0.850	0.309	0.884
Intracerebral Haemorrhage	0.765	0.989	0.391	0.831	0.665
Arm weakness on admission	0.980	0.890	0.366	0.992	0.139
Impaired speech on admission	0.432	0.943	0.650	0.213	<b>0.021</b>
Unable to walk on admission	<b>0.046</b>	0.430	0.429	0.253	0.610
Incontinence at 72 hours of admission	0.842	0.708	0.747	0.334	0.649
Atrial fibrillation	0.281	0.274	0.899	0.812	0.565
Ischaemic heart disease	0.186	0.693	0.927	<b>0.007</b>	0.611
Transferred to SU within 3 hours of ED arrival	-	-	-	0.704	<b>0.041</b>
Severe complication	<b>0.013</b>	-	-	0.704	0.051

There were no differences between treatment groups within quintiles of the propensity score where there was good matching of characteristics between treatment groups (Table D). Death was predicted perfectly in the model within quintile 4.

<b>Table D. Adjusted beta coefficient for differences between treatment groups (Model A)</b>			
<b>β coefficient (95% confidence interval), p-value</b>			
<b>reference category: &lt;90% time spent in a stroke unit</b>			
<b>Quintile</b>	<b>Death</b>	<b>Discharged to residential aged care</b>	<b>Length of stay (discharged patients)</b>
1	<b>-0.48 (-0.93, -0.04), 0.03</b>	<b>-0.63 (-1.26, -0.01), 0.047</b>	<b>-5.0 (-9.49, -0.51), 0.03</b>
2	-0.41 (-1.50, 0.69), 0.47	0.03 (-0.83, 0.88), 0.95	<b>-2.0 (-3.60, -0.40), 0.01</b>
3	-0.63 (-3.43, 2.17), 0.66	-0.51 (-1.46, 0.43), 0.29	<b>-3.0 9-4.41, -1.60), &lt;0.001</b>
4	-	<b>-1.59 (-2.99, -0.20), 0.025</b>	-1.0 (-2.00, 0.003), 0.051
5	-0.66 (-1.52, 0.30), 0.18	<b>-1.98 (-3.40, -0.57), 0.006</b>	<b>-3.0 (-4.34, -1.67), &lt;0.001</b>
2 and 3	-0.43 (-1.46, 0.60), 0.411	-0.15 (-0.81, 0.51), 0.662	<b>-2.0 (-2.99, -1.01), &lt;0.001</b>
Overall	<b>-0.43 (-0.82, -0.05), 0.026</b>	<b>-0.62 (-1.07, -0.16), 0.008</b>	<b>-3.0 (-4.01, -1.99), &lt;0.001</b>



**Propensity score generated excluding severe complications as a variable in the multivariable logistic regression model (Model B)**

A propensity score was generated for 746 patients who spent <90% of their admission in a stroke unit and 1387 patients who spent  $\geq$ 90% of their admission in a stroke unit.

<b>Numbers of patients within the quintiles of the propensity score (Model B)</b>		
	<b>&lt;90% time spent in a stroke unit</b>	<b><math>\geq</math>90% time spent in a stroke unit</b>
<b>Propensity score quintiles</b>	<b>N</b>	<b>N</b>
1	186	241
2	169	258
3	148	278
4	147	280
5	96	330
Total	746	1387

There were fewer differences in the characteristics of patients apparent between the treatment groups within the quintiles of the propensity score when severe complications were not considered in the propensity score.

Within quintile 4, there were difference between treatment groups in the proportion of patients who had impaired speech on admission ( $p=0.032$ ) and had a previous history of ischaemic heart disease ( $p=0.011$ ).

Within quintile 5, there was a difference between treatment groups in the proportion of patients who were transferred to the stroke unit within 3 hours of arrival to the emergency department ( $p=0.012$ ).

In quintiles 1, 2, 3 and 4 all patients were not transferred to the stroke unit within 3 hours of arrival to the emergency department.

<b>Differences in characteristics between treatment groups within quintiles (Model B)</b>					
	<b>p-values for differences in characteristics between treatment groups within quintiles</b>				
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
Age	0.346	0.386	0.851	0.944	0.908
Intracerebral Haemorrhage	0.390	0.718	0.466	0.226	0.695
Arm weakness on admission	0.544	0.674	0.547	0.696	0.498
Impaired speech on admission	0.299	0.906	0.845	<b>0.032</b>	0.095
Unable to walk on admission	0.938	0.228	0.512	0.135	0.275
Incontinence at 72 hours of admission	0.552	0.555	0.765	0.468	0.811
Atrial fibrillation	0.536	0.349	0.945	0.912	0.675
Ischaemic heart disease	0.363	0.861	0.223	<b>0.011</b>	0.780
Transferred to SU within 3 hours of ED arrival	-	-	-	-	<b>0.012</b>

There were differences between treatment groups within quintiles of the propensity score where there was good matching of characteristics between treatment groups (Table E). There was a reduced chance of severe complications with greater time spent on a stroke unit within quintile 3 (p=0.013). When quintiles 1, 2 and 3 were aggregated, there was a reduced chance of severe complication (p=0.002) and death in hospital (p=0.039) with greater time spent on a stroke unit. Death was predicted perfectly in the model within quintile 4.

<b>Table E. Adjusted beta coefficient for differences between treatment groups (Model B)</b>				
<b>β coefficient (95% confidence interval), p-value</b>				
<b>reference category: &lt;90% time spent in a stroke unit</b>				
<b>Quintile</b>	<b>Severe complication</b>	<b>Death</b>	<b>Discharged to residential aged care</b>	<b>Length of stay (discharged)</b>
1	-0.41 (-0.86, 0.03), 0.069	-0.47 (-0.98, 0.04), 0.069	-0.49 (-1.06, 0.08), 0.091	<b>-5.0 (-7.74, -2.26),</b> <b>&lt;0.001</b>
2	-0.36 (-1.07, 0.36), 0.328	-0.08 (-0.89, 0.73), 0.847	-0.17 (-0.96, 0.60), 0.664	<b>-2.0 (-3.08, -0.92),</b> <b>&lt;0.001</b>
3	<b>-1.14 (-2.04, -0.24),</b> <b>0.013</b>	-1.05 (-2.86, 0.76), 0.255	-0.67 (-1.64, 0.31), 0.183	<b>-3.0 (-4.01, -1.99),</b> <b>&lt;0.001</b>
4	-0.10 (-1.33, 1.14), 0.877	-	-1.35 (-2.88, 0.18), 0.083	<b>-1.0 (-1.87, -0.13),</b> <b>0.025</b>
5	<b>-0.89 (-1.52, -0.15),</b> <b>0.018</b>	-0.57 (-1.51, 0.36), 0.228	<b>-1.73 (-3.22, -0.24),</b> <b>0.023</b>	<b>-3.0 (-4.15, -1.85),</b> <b>&lt;0.001</b>
1, 2 and 3	<b>-0.49 (-0.81, -0.18),</b> <b>0.002</b>	<b>-0.40 (-0.77, -0.02),</b> <b>0.039</b>	-0.42 (-0.86, 0.02), 0.058	<b>-3.0 (-3.77, -2.22),</b> <b>&lt;0.001</b>
Overall	<b>-0.52 (-0.81, -0.23),</b> <b>0.001</b>	<b>-0.41 (-0.77, -0.05),</b> <b>0.026</b>	<b>-0.59 (-1.02, -0.15),</b> <b>0.008</b>	<b>-3.0 (-3.80, -2.20),</b> <b>&lt;0.001</b>

### **Interpretation of propensity score matching analyses**

There is some evidence of benefit from a greater proportion of time spent in a stroke unit when confounding by indication is controlled

**Supplemental Table F. Association between percentages of hospital stay spent in a stroke unit and in-hospital outcomes of patients with stroke**

<b>Model</b>	<b>Percentage of time spent in a SU (%)</b>	<b>aOR<sup>a</sup></b>	<b>95% CI</b>	<b>P-value</b>
1	Any severe Complications <sup>b</sup>			
	< 50	1		
	≥50 to <60	1.35	(0.68, 2.69)	0.40
	≥60 to <70	0.56	(0.23, 1.36)	0.20
	≥70 to <80	0.54	(0.23, 1.26)	0.15
	≥80 to <90	0.51	(0.25, 1.05)	0.07
	≥90	<b>0.47</b>	<b>(0.30, 0.74)</b>	<b>0.001</b>
2	LOS less than or equal to median LOS (5 days) - discharged			
	< 50	1		
	≥50 to <60	<b>7.31</b>	<b>(4.12, 12.97)</b>	<b>&lt;0.001</b>
	≥60 to <70	<b>9.15</b>	<b>(5.14, 16.27)</b>	<b>&lt;0.001</b>
	≥70 to <80	<b>6.31</b>	<b>(3.52, 11.31)</b>	<b>&lt;0.001</b>
	≥80 to <90	<b>2.27</b>	<b>(1.28, 4.02)</b>	<b>0.005</b>
	≥90	<b>9.71</b>	<b>(6.42, 14.69)</b>	<b>&lt;0.001</b>
3	Independent at discharge (mRS 0-2)			
	< 50	1		
	≥50 to <60	1.67	(0.90, 3.10)	0.10
	≥60 to <70	1.61	(0.89, 2.91)	0.11
	≥70 to <80	<b>2.02</b>	<b>(1.08, 3.79)</b>	<b>0.03</b>
	≥80 to <90	1.07	(0.60, 1.90)	0.82
	≥90	<b>1.57</b>	<b>(1.07, 2.28)</b>	<b>0.02</b>

SU: stroke unit; aOR: adjusted odds ratio; CI: confidence interval; LOS: length of stay; mRS: modified Rankin scale. <sup>a</sup>Models adjusted for age, gender, premorbid function, stroke type, stroke severity and past history of atrial fibrillation. <sup>b</sup>a complication considered incapacitating, life threatening and one that prolongs hospital admission and patient acuity including pneumonia, falls, fever, urinary tract infection, seizures, deep vein thrombosis etc.