






BMJ Open Regional differences in the care and outcomes of acute stroke patients in Australia: an observational study using evidence from the Australian Stroke Clinical Registry (AuSCR)

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ABSTRACT

Objective To compare the processes and outcomes of care in patients who had a stroke treated in urban versus rural hospitals in Australia.

Design Observational study using data from a multicentre national registry.

Setting Data from 50 acute care hospitals in Australia (25 urban, 25 rural) which participated in the Australian Stroke Clinical Registry during the period 2010–2015.

Participants Patients were divided into two groups (urban, rural) according to the Australian Standard Geographical Classification Remoteness Area classification. Data pertaining to 28 115 patients who had a stroke were analysed, of whom 8159 (29%) were admitted to hospitals located within rural areas.

Primary and secondary outcome measures Regional differences in processes of care (admission to a stroke unit, thrombolysis for ischaemic stroke, discharge on antihypertensive medication and provision of a care plan), and survival analyses up to 180 days and health-related quality of life at 90–180 days.

Results Compared with those admitted to urban hospitals, patients in rural hospitals less often received thrombolysis (urban 12.7% vs rural 7.5%, $p<0.001$) or received treatment in stroke units (urban 82.2% vs rural 76.5%, $p<0.001$), and fewer were discharged with a care plan (urban 61.3% vs rural 44.7%, $p<0.001$). No significant differences were found in terms of survival or overall self-reported quality of life.

Conclusions Rural access to recommended components of acute stroke care was comparatively poorer; however, this did not appear to impact health outcomes at approximately 6 months.

INTRODUCTION

Internationally, evidence suggests that patients who had a stroke admitted to hospitals located in rural or regional areas have limited access to known evidence-based interventions, such as thrombolysis and stroke unit

Strengths and limitations of this study

- This is the first study in Australia to look at how access to acute stroke care varies between Australia's urban and rural areas, using data from the Australian Stroke Clinical Registry (AuSCR).
- This study also reports on regional differences in patient outcomes in the form of mortality and health-related quality of life at up to 180 days poststroke.
- Patient outcome measures were adjusted for known confounders.
- Hospitals participating in the AuSCR may not be representative of all Australian hospitals.

care, relative to those treated in urban hospitals.¹ There is a paucity of research investigating disparities in other, more elementary processes which define contemporary standards of acute stroke care, such as the prescription of secondary prevention medications. In addition, if there are differences in stroke care between urban and rural regions, determining if there are corresponding differences in patient outcomes warrants attention so as to permit future exploration of organisational, process or patient barriers preventing evidence-based stroke care being received.

Overall, prior research on the rural and urban outcomes of care has yielded inconsistent findings,¹ and is characterised by studies with inadequate risk adjustment^{2–4} or an indirect focus on urban–rural differences in outcomes.^{5–7} Previous attempts to explore this issue have also been reliant on ‘hard’ outcome measures such as rates of mortality and readmission,^{8–10} whereas regional differences in patients’ quality of life have been

rarely investigated.^{11 12} Given this knowledge gap, the aim of this study was to compare the processes of care and outcomes for patients who had a stroke treated in urban compared with rural hospitals.

METHODS

Study design

We undertook a multicentre observational cohort study of adults admitted to hospital who had acute stroke using linked data from the Australian Stroke Clinical Registry (AuSCR) (see protocol¹³ and www.auscr.com.au). The AuSCR is used to monitor processes of care provided to, and the outcomes of, individuals hospitalised with acute stroke or transient ischaemic attacks (TIAs) in Australian hospitals primarily for quality improvement and benchmarking activities.¹³ Cases are entered prospectively in the AuSCR based on clinical diagnosis of stroke during admission. Case ascertainment is checked annually using International Classification of Diseases-10 discharge codes obtained from the hospital administrative system and compared with the cases entered in the registry at each hospital. A complete list of coinvestigators and other contributors to the AuSCR is found in online supplemental file 1. Death information (date and cause) from Australia's National Death Index is routinely linked to the AuSCR by the Australian Institute of Health and Welfare.¹⁴ For this study, we used data from all 50 hospitals that submitted data to the AuSCR from January 2010 to December 2015. Patients diagnosed with TIAs were excluded from the analyses as these individuals are unlikely to require the care processes of interest in this study. As of 2015, the 50 hospitals covered by the AuSCR accounted for approximately 46% of all Australian hospitals receiving ≥ 50 stroke admissions per annum.¹⁵ Selection bias is minimised in the AuSCR by use of an 'opt-out' approach when recruiting participants, whereby all eligible patients are registered unless they or their next of kin nominates to have their data excluded.¹³ The proportion of cases who opt out from the registry is $< 3\%$ in urban and rural hospitals. Patients who did not opt out of the registry and who were discharged from hospital following their stroke were followed up by trained research staff between 90 and 180 days after their index admission (ie, the first registered event in AuSCR). This process uses a modified Dillman protocol,¹⁶ whereby two attempts are made to contact patients by post prior to an attempt by telephone.¹⁷

Process of care data collected in AuSCR up to 2015 were admission to a stroke unit, thrombolysis (ischaemic stroke only), discharge on antihypertensive medication and provision of a care plan. Care plans are developed with the patient and family if discharged from acute care directly to the community (ie, to a home setting or institutional residential aged care and not transferred to another hospital, ie, for rehabilitation). This is not the discharge summary written by hospital clinicians for the primary care doctor; the discharge care plan should

include information to improve the transition to home, such as arrangements for community support services, information on risk factor management, equipment to be purchased and follow-up appointments. Hospitals located in the state of Queensland also collected four additional variables: time to first mobilisation, dysphagia screen, aspirin within 48 hours and being discharged on antiplatelets or antithrombotics in case of an ischaemic event. Indicator data with responses of no, unknown or missing were recoded as negative (the proportion of missing data ranged from $< 1\%$ to 5.05%). Regional differences in patient mortality were assessed using intervals of 7, 30, 90 and 180 days.

Participants' health-related quality of life (HRQoL) data were collected at 90–180 days of follow-up using the EuroQoL-5 Dimension-3 Level (EQ-5D-3L) instrument.¹⁸ Respondents were asked to report their health status in five domains (mobility, self-care, usual activities, pain or discomfort, and anxiety or depression), with each domain having three possible responses (no problems, some problems and extreme problems). Respondents used a Visual Analogue Scale (VAS) to rate their overall perceived health from 0 to 100, with 0 being the worst imaginable health state and 100 the best imaginable health state.¹⁸ The VAS was coded as 0 for individuals who had died within the follow-up period.

Statistical analysis

The primary exposure variable of interest was classification of hospital (urban vs rural), and the primary outcomes were survival analyses up to 180 days and HRQoL as assessed on the EQ-5D-3L. Hospitals were divided into categories of 'urban' or 'rural' based on their classification under the Australian Standard Geographical Classification Remoteness Area (ASGC-RA) system.¹⁹ The ASGC-RA system classifies areas into five categories: major cities, inner regional, outer regional, remote or very remote.¹⁹ For the purpose of this study, hospitals located in ASGC-RA category 1 (ie, major cities) were regarded as 'urban', while those in categories 2 or above were regarded as 'rural'. Interactive maps with overlays of the remoteness area categories can be accessed via the Australian Bureau of Statistics website.²⁰ The majority of hospitals ($> 95\%$) that contribute data to AuSCR are funded under the public healthcare scheme. Participants' baseline characteristics were compared between regions using χ^2 tests for categorical data and Wilcoxon rank-sum tests for continuous variables. Care processes were expressed as the proportion of eligible patients who received each form of care and were analysed by location (urban or rural) using χ^2 tests. Participants' responses to the EQ-5D-3L instrument were expressed as the number of individuals who encountered problems with each domain, with 'some problems' and 'extreme problems' being recoded into one category. Regional differences within each domain were then analysed using χ^2 tests.

Cox proportional hazards regression analysis was conducted to assess deaths within 7, 30, 90 and 180 days.

Logistic regression was used to assess regional differences in each of the EQ-5D-3L domains. Models were adjusted for age, sex, year of admission, state, type of stroke, ability to walk on admission (as a validated measure of stroke severity)²¹ and socioeconomic status (SES) using the Index of Relative Socio-economic Advantage and Disadvantage.²² Each regression model also accounted for interhospital transfers, in-hospital stroke and whether the individual received treatment in a stroke unit. Patient clustering was adjusted for directly in each of our models to account for correlation between patients admitted to the same hospital. A sensitivity analysis was undertaken using data sets where interhospital transfers were excluded to assess the potential impact of this variable on patient outcomes. Data were analysed using Stata/SE V.12.²³

Patient and public involvement

Patients and/or the public were not directly involved in the design, recruitment or implementation of the study. Consumer representatives are members of the AuSCR Steering Committee, and regular reviews by consumers of the AuSCR documents (policies and reports) are undertaken.

RESULTS

Between 2010 and 2015, 28 115 episodes of care from 50 hospitals were registered in the AuSCR. Of these episodes, 8159 (29%) were for individuals admitted to hospitals located within rural areas. Compared with those from urban areas, individuals from rural areas were more likely to have been born in Australia, have an indigenous background and be of a lower SES (table 1). Rural patients were also more likely than urban patients to be diagnosed with a stroke of 'undetermined' subtype (8.1% vs 3.6%). When compared with urban patients, those treated in rural hospitals had poorer access to several clinical processes of care (table 2; online supplemental file 2 for variables collected only in Queensland). Specifically, rural patients were less likely to be admitted to a stroke unit (OR=0.70, 95% CI 0.66 to 0.74), receive intravenous thrombolysis in ischaemic stroke (OR=0.55, 95% CI 0.50 to 0.62) or be provided with a care plan at time of discharge (OR=0.59, 95% CI 0.54 to 0.64). There were no significant differences between regions in the prescribing rates of antihypertensive medications at discharge (OR=0.97, 95% CI 0.91 to 1.03). Regional differences in the proportion of patients discharged home were not observed, but urban patients were more likely to die in hospital in the unadjusted comparisons (table 2). The median length of stay for rural patients was 1 day shorter than that of urban patients, and this remained the case after adjustment for potential confounders (coefficient -1, 95% CI -1.97 to -0.03).

There were no significant differences between geographical groups in terms of survival up to 180 days (table 3). In relation to HRQoL, no regional differences were observed in four of the EQ-5D domains, namely

anxiety/depression, mobility, self-care and usual activities (table 4). Rural patients were, however, significantly less likely to have reported symptoms of pain or discomfort during the follow-up period (OR=0.88, 95% CI 0.79 to 0.97, $p=0.015$). Rural patients also had marginally higher perceived health, as measured by VAS, than their urban counterparts (70 vs 68, $p<0.001$). The sensitivity analysis that excluded transferred patients did not influence the results.

DISCUSSION

The primary aim of this study was to assess whether there are differences in the quality of care and outcomes for patients treated in urban and rural locations. We found that patients admitted to rural hospitals in Australia were less likely to receive some key care processes that are recommended in our national stroke clinical guidelines.²⁴ However, for the most part, we did not observe corresponding differences in patient outcomes at 90–180 days.

Patients admitted to rural hospitals were significantly less likely to receive treatment in a stroke unit (76.5% vs 82.2%) despite only one rural hospital not being equipped with a stroke unit ($n=30$ episodes of care). This finding suggests that while nearly all rural sites had facilities which met the minimum criteria for stroke units,²⁵ many were unable to use their stroke unit's full potential. As observed by Dwyer,²⁶ hospitals without 'quarantined' stroke unit beds may be unable to offer specialist care to patients who had a stroke at times when there is demand for beds from other medical specialties. Such hospitals may benefit from using clinical coordinators to facilitate organisational change, as recommended by Cadilhac and colleagues.²⁷

It should be noted that during the study period only 45% of patients located in Australia's 'regional' areas received treatment in a stroke unit and only 3.3% of all stroke unit beds were located in regional areas.^{28 29} Taken together, these statistics indicate that access to stroke units within rural hospitals participating in the AuSCR was markedly better than the national average. Given that there is a well-established link between stroke unit admission and access to key aspects of acute stroke care,³⁰ future efforts should focus on increasing the number of stroke units within Australia's regional areas and improving access to existing stroke units. Adherence rates in the current study were, for the most part, representative of that of more recent stroke care audits in Australia.^{31 32} The main exception was in rates of care plan provision; on average 53% of patients in the current study received this form of care, which was substantially lower than that of AuSCR data from 2018 (69%)³² and data from the Stroke Foundation's 2019 Acute Audit (65%).³¹

Consistent with other studies, rural patients remained less likely than urban patients to be administered thrombolysis. The provision of thrombolysis is known to be influenced by a host of patient, clinician and system-related factors.³³ Of these factors, patients' distance

**Table 1** Patient characteristics by region

Characteristics	Urban, n (%)	Rural, n (%)	P value
Number of sites	25 (50)	25 (50)	
Number of cases	19956 (71)	8159 (29)	
Female	9095 (45.6)	3770 (46.2)	0.335
Age (years)			
<65	4910 (24.6)	2095 (25.7)	0.030
65–74	4468 (22.4)	1887 (23.1)	
75–84	6141 (30.8)	2469 (30.3)	
85+	4431 (22.2)	1707 (20.9)	
Median age in years (Q1, Q3)*	76.1 (65.2, 84.2)	75.4 (64.7, 83.6)	0.003
State			
New South Wales	3252 (16.3)	805 (9.9)	<0.001
Queensland	6675 (33.4)	4401 (53.9)	
Tasmania	–	1118 (13.7)	
Victoria	9133 (45.8)	1835 (22.5)	
Western Australia	896 (4.5)	–	
Born in Australia	11916 (59.7)	6282 (77)	<0.001
Aboriginal/Torres Strait Islander	174 (0.9)	262 (3.2)	<0.001
Index of Relative Socio-Economic Advantage and Disadvantage			
Quintile 1 (most disadvantaged)	2367 (12.3)	2557 (34.4)	<0.001
Quintile 2	2764 (14.3)	1932 (26)	
Quintile 3	3335 (17.3)	1603 (21.6)	
Quintile 4	4837 (25.1)	1092 (14.7)	
Quintile 5 (most advantaged)	5986 (31)	244 (3.3)	
Able to walk on admission (stroke severity)	6055 (32.7)	2439 (34.6)	0.003
Stroke subtype			
Intracerebral haemorrhagic	3247 (16.3)	1177 (14.4)	<0.001
Ischaemic	15962 (80.1)	6313 (77.5)	
Undetermined	709 (3.6)	658 (8.1)	
Transfer from other hospitals	2191 (11.2)	1739 (21.6)	<0.001
In-hospital stroke	1156 (5.9)	407 (5.1)	0.008
Length of stay, median (Q1, Q3)* days	6 (3, 10)	5 (2, 8)	<0.001
Died in hospital†	2216 (11.3)	720 (9.5)	<0.001
Discharge destination			
Home	7353 (41.4)	2899 (39)	0.092
Rehabilitation	6234 (35.1)	2137 (28.7)	<0.001
Aged care	1057 (6)	326 (4.4)	<0.001
Other	3096 (17.5)	2077 (27.9)	<0.001
EQ-5D domains			
Mobility			
No problems	4171 (47.1)	1791 (48.4)	
Some problems	4056 (45.8)	1714 (46.4)	
Extreme problems	631 (7.1)	193 (5.2)	<0.001
Self-care			
No problems	5784 (65.2)	2499 (67.4)	
Some problems	2012 (22.7)	872 (23.5)	

Continued

Table 1 Continued

Characteristics	Urban, n (%)	Rural, n (%)	P value
Extreme problems	1069 (12.1)	339 (9.1)	<0.001
Usual activities			
No problems	3445 (38.9)	1448 (39.1)	
Some problems	3590 (40.6)	1571 (42.3)	
Extreme problems	1809 (20.5)	688 (18.6)	0.034
Pain/discomfort			
No problems	4401 (50)	1876 (50.9)	
Some problems	3955 (44.9)	1622 (44)	
Extreme problems	446 (5.1)	190 (5.1)	0.621
Anxiety/depression			
No problems	4632 (52.8)	1948 (52.9)	
Some problems	3630 (41.3)	1527 (41.5)	
Extreme problems	518 (5.9)	208 (5.6)	0.860

*Q1: 25th percentile; Q3: 75th percentile.

†<5% missing/not documented data.

EQ-5D, EuroQoL-5 Dimension.

to hospitals, accessing brain imaging after-hours and obtaining specialist input are among the most pertinent issues encountered by clinicians providing thrombolysis in rural areas.^{34–36} Rural-based clinicians in the Australian state of Victoria have been able to obtain specialist input and improve thrombolysis rates through the use of a telemedicine programme.³⁷ Such a system was implemented in the state of Victoria for a small part of the study period,³⁷ and as such may have influenced adherence rates in this group of hospitals. The use of telemedicine technology in all regional areas of the country is urgently needed in order to increase rates of thrombolysis administration.³⁸

We did not observe differences by location in rates of prescription for antihypertensive medications at hospital discharge. As has been noted previously,³⁹ this may reflect the fact that the management of patients' blood pressure for primary or secondary prevention is not necessarily specific to stroke and does not require any additional resources. In any case, the rates

of prescription for antihypertensive medications at discharge from both regions were substantially less than expected based on previous AuSCR data, indicating that more work needs to be done to improve this aspect of evidence-based care.⁴⁰

Despite marked differences in access to stroke unit care and thrombolysis, we did not observe any regional differences in rates of survival at up to 180 days poststroke. This may be because access to acute stroke care, when considered in its entirety, was reasonably comparable between the study's urban and rural hospitals. This notion is supported by the fact that the study's rural hospitals, by virtue of their participation in the registry, are likely to be highly motivated to monitor and improve their provision of stroke care and perhaps are better resourced than other rural sites. Furthermore, there is evidence that within the state of Queensland (online supplemental file 2) patients in rural hospitals were provided evidence-based therapies

Table 2 Processes of care by region

	Urban, n (%)	Rural, n (%)	P value
Evidence-based therapies (all states)			
Treated in a stroke unit	16 408 (82.2)	6241 (76.5)	<0.001
Intravenous thrombolysis for ischaemic stroke	2007 (12.7)	463 (7.5)	<0.001
Discharged on antihypertensives	12 184 (70.6)	4895 (69.9)	0.315
Care plan on discharge to community	4871 (61.3)	1441 (44.7)	<0.001

Table 3 Survival analysis of rural patients who had a stroke as compared with urban patients

Time to death	Urban	Rural	p value	Model*	
	n (%)	n (%)		HR	95% CI
Up to 7 days	1750 (8.8)	769 (9.4)	0.081	0.98	0.79 to 1.21
8–30 days	1242 (6.2)	491 (6)	0.608	1.02	0.87 to 1.20
31–90 days	745 (3.7)	265 (3.2)	0.055	0.88	0.73 to 1.06
91–180 days	526 (2.6)	202 (2.5)	0.439	0.88	0.69 to 1.11

*Models were adjusted for age, sex, year of admission, state, type of stroke, ability to walk on admission, socioeconomic status, interhospital transfers, in-hospital stroke and stroke unit admission.

**Table 4** Outcomes at 90–180 days of follow-up of rural patients as compared with urban patients

EQ-5D domains	Urban, n (%)	Rural, n (%)	P value	Model*		
				OR	95% CI	P value
Mobility	4687 (52.9)	1907 (51.6)	0.169	1.02	0.92 to 1.13	0.717
Self-care	3081 (34.8)	1211 (32.6)	0.023	0.92	0.80 to 1.06	0.235
Usual activities	5399 (61)	2259 (60.9)	0.910	0.95	0.85 to 1.06	0.376
Pain/discomfort	4401 (50)	1812 (49.1)	0.376	0.88	0.79 to 0.97	0.015
Anxiety/depression	4148 (47.2)	1735 (47.1)	0.890	0.98	0.87 to 1.10	0.759
Median Visual Analogue Scale score (Q1, Q3)	68 (40, 80)	70 (50, 83)	<0.001	–	–	–

*Models were adjusted for age, sex, year of admission, state, type of stroke, ability to walk on admission, socioeconomic status, interhospital transfers, in-hospital stroke and stroke unit admission. EQ-5D, EuroQoL-5 Dimension.

more often than those in urban hospitals. These differences warrant further research.

In relation to HRQoL, we observed that with the exception of the pain/discomfort domain, there were no significant regional differences in any of the EQ-5D domains or VAS scores. These findings stand in contrast to multiple surveys conducted by the Australian government in which rural residents had an overall lower self-reported health status.^{41 42} The disparity between regions in terms of self-reported pain/discomfort may point towards regional differences in attitudes towards pain management. Indeed, literature on patients with cancer in Australia has highlighted that a culture of stoicism and self-reliance within rural areas can make individuals less likely to report symptoms of pain⁴³ and delay seeking medical assistance.⁴⁴ There are other demographic factors which may partially explain this finding. For instance, previous researchers using the AuSCR data have found that patients who had a stroke requiring an interpreter are more likely to report symptoms of pain.⁴⁵ Given that urban patients in this study were far less likely to have been born in Australia (ie, 59.7% vs 77%), the impact of the respondents' English-speaking ability on our findings cannot be discounted. Previous research using the AuSCR data has also highlighted that, other factors remaining equal, younger people from a lower SES are more likely to report symptoms of anxiety/depression.⁴⁶ We also found that rural patients had a significantly higher perceived health status than urban patients (70 vs 68 via VAS); however, it is unlikely that this difference represents a clinically relevant finding.⁴⁷

Our study design and data have several limitations. First, we report data only up to 2015. As with clinical quality registries internationally,⁴⁸ there is a delay in creating aggregate national samples from local sites due to data sharing, ethics and cleaning delays. Ongoing reporting of the AuSCR data to continue to monitor quality of care and outcomes for patients treated in urban and rural locations will ensure continued monitoring of this issue. Specific to this comparison, we acknowledge that the distribution of urban and rural patients in this study

(71% vs 29%) may not reflect that of the broader Australian hospital population, which recently stood at 64% and 36%, respectively.⁴⁹ We also did not use any data in relation to participants' residential addresses. It is therefore possible that some individuals who were admitted to urban hospitals resided in rural areas and vice versa. A further limitation is that our HRQoL data did not factor in patients' health prior to their stroke, meaning it is possible that some individuals' HRQoL deficits may relate to pre-existing conditions. Lastly, although we used patients' baseline walking ability as a validated measure of stroke severity,²¹ the study may have benefited from the use of a more recognised scale, such as the National Institutes of Health Stroke Scale. Despite these limitations, our study is the first of its kind in Australia to comprehensively examine urban–rural differences in access to acute stroke care and the associated patient outcomes. To the best of the authors' knowledge, it is also among the first in the world to report on urban–rural differences in patients' quality of life poststroke.

CONCLUSIONS

This is the largest study to date examining geographical disparities in processes of stroke care and providing a benchmark for the development and testing of interventions that may have the potential to reduce the differences between rural and urban patients who had acute stroke. Interestingly, while we identified disparities in processes of care, we did not observe any association between geographical region and patient outcomes in terms of mortality or HRQoL. There are clear opportunities to better understand why the impact of these process of care variables on stroke outcomes are more pronounced in urban areas. Our findings underscore the importance of understanding how geographical area influences HRQoL and in turn how population disparities (such as life expectancy, income and indigenous status) across geographical areas may contribute to these differences; continued efforts to determine the impact of stroke care postdischarge are important. Future work in

this field should also focus on redressing the resourcing disparities, in particular increasing the number of rural hospitals which meet the minimum criteria for stroke unit care.

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Contributors HC, MD, GMP, SG, KFo, KFr and DAC contributed to study design and concept. JK and DAC contributed to statistical analyses. HP, HC, LW, RW, FR and LA participated in manuscript preparation, editing and revision, and agreed on the final version of the paper. NAL contributed to interpretation of results and was heavily involved in the final preparation of the paper.

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Online Supplement 2 – Queensland Specific Care Processes

Care Process	Urban <i>n</i> (%)	Rural <i>n</i> (%)	p-value
Mobilised during admission	2,876 (69.3)	1,950 (80.1)	<0.001
Swallow screen or assessment	4,952 (74.2)	3,676 (83.5)	<0.001
Aspirin within 48h, if ischaemic	3,393 (68.2)	2,843 (75.8)	<0.001
Discharged on antithrombotic medication, if ischaemic	3,823 (80.1)	2,694 (86.7)	<0.001