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Geographic Disparities in Stroke Outcomes and Service Access: A Prospective Observational Study

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## Abstract

### Background and objective

International evidence shows that patients treated at non-urban hospitals experience poorer access to key stroke interventions. Evidence whether this results in poorer outcomes is conflicting and generally based on administrative or voluntary registry data. The aim of this study was to use prospective high-quality comprehensive nationwide patient level data to investigate the association between hospital geography and stroke patient outcomes and access to best practice stroke care in New Zealand.

### Methods

This is a prospective, multi-centre, nationally representative observational study involving all 28 New Zealand acute stroke hospitals (18 non-urban), and affiliated rehabilitation and community services. Consecutive adults admitted to the hospital with acute stroke between 1 May and 31 October 2018 were captured. Outcomes included functional outcome (modified Rankin Scale (mRS) shift analysis), functional independence (mRS scores 0-2), quality of life (EQ5D-3L), stroke/vascular events, and death at 3, 6, and 12 months and proportion accessing thrombolysis, thrombectomy, stroke units, key investigations, secondary prevention, and inpatient/community rehabilitation. Results were adjusted for age, sex, ethnicity, stroke severity/type, co-morbidities, baseline function, and differences in baseline characteristics.

### Results

Overall, 2,379 patients were eligible (mean (standard deviation) age 75 (13.7); 51.2% male; 1,430 urban; 949 non-urban). Patients treated at non-urban hospitals were more likely to

score in a higher mRS category (greater disability) at three (aOR=1.28, 1.07-1.53), six (aOR=1.33, 1.07-1.65) and twelve months (aOR=1.31, 1.06-1.62) and were more likely to have died (aOR=1.57, 1.17-2.12) or experienced recurrent stroke and vascular events at 12 months (aOR=1.94, 1.14-3.29 and aOR=1.65, 1.09-2.52). Fewer non-urban patients received recommended stroke interventions including endovascular thrombectomy (aOR=0.25, 95% confidence interval 0.13-0.49), acute stroke unit care (aOR=0.60, 0.49-0.73), antiplatelet prescriptions (aOR=0.72, 0.58-0.88),  $\leq$ 60 minutes daily physical therapy (aOR=0.55, 0.40-0.77) and community rehabilitation (aOR=0.69, 0.56-0.84).

## Discussion

Patients managed at non-urban hospitals experience poorer stroke outcomes and reduced access to key stroke interventions across the entire care continuum. Efforts to improve access to high quality stroke care in non-urban hospitals should be a priority.

## **Introduction**

Globally, stroke is a leading cause of death and disability.<sup>1</sup> Organised stroke care, both in the acute and rehabilitation settings has been shown to result in a greater likelihood of patient survival, independence and returning home.<sup>2</sup>

New Zealand has a population of 4.9 million people dispersed over an area of 268,021 km ranking 126 in population density globally. Health care is predominantly provided via a publicly funded single payer universal coverage system with a small private sector offering elective surgeries and ambulatory specialist consultations. As a result, all acute stroke services are offered via the government funded public health sector at 28 acute hospitals. Co-payments are required for general practitioner (GP) visits, most ambulance services, and medications (NZ\$5 per prescription). Public hospital services including post-discharge



community rehabilitation and specialist follow-up are free of charge without co-payments. Funding is allocated based on the population served by each of 20 health districts. Additional subsidies are provided to rural hospitals with low population density and where there are higher proportions of older people or of indigenous Māori ethnicity. Finally, there is a tertiary adjuster allocated to centres providing high-cost tertiary services.

Departures from best practice stroke care in smaller, non-urban New Zealand hospitals have been accepted where a small population is dispersed over a wide geographic area.<sup>3</sup> For example, these hospitals have not been required to have a geographically designated stroke unit or stroke specific rehabilitation service, with stroke care provided either by general teams or by non-ward based 'mobile stroke teams' which generally comprise a physician, a specialty nurse, and often non-stroke team specific allied health clinicians. Within these settings patients are often treated by clinicians without specific training in stroke care. It is unclear to what degree, if any, these compromises affect patient outcomes.

In recent years, authors of New Zealand stroke service surveys have found that significant regional variations in the implementation of best practice care continue to exist, despite significant work that has gone into implementing best practice stroke care.<sup>4,5</sup> International research reports that patients admitted to non-urban hospitals have poorer access to key stroke interventions compared to those admitted to urban hospitals,<sup>6,7</sup> although there is conflicting evidence regarding the impact of hospital geographic location on patient outcomes.<sup>6,8,9</sup> The aim of this study was to determine the extent of stroke care access inequities and the degree to which this affects patient outcomes in New Zealand.

## **Methods**

REGIONS Care (Reducing Ethnic and Geographic Inequities to Optimise New Zealand Stroke Care) is a multi-part nationwide prospective observational study designed to assess the

impact of geography and ethnicity on stroke outcomes and access to best practice care. It involves a comprehensive nationwide stroke dataset with a sub-set of patients recruited to undergo extended follow-up, data linkage with health administrative data, focus groups and surveys. Here we report the results of the analysis based on geographic location (urban or non-urban). Full study methods, including prospective sample size calculations and analysis plan, have been described elsewhere.<sup>10</sup>

#### Study sample:

This study involved all 28 New Zealand hospitals and associated rehabilitation and community services caring for patients with acute stroke. All adult patients admitted to hospital between 1 May and 31 July 2018 with a discharge diagnosis of stroke were captured. After this date, we continued consecutive patient recruitment until hospitals achieved a minimum sample size of 150 (thrombectomy centres) or 100 (all other centres) or until 31 October 2018, whichever occurred first. We grouped hospitals into urban and non-urban centres, defining urban as any hospital located within a 30-minute drive (<25 km) of an urban area comprising a population of more than 100,000 people. The study was powered to detect a 10% difference in favourable outcome at 90% power with alpha 0.05 between groups up to 12 months.

Patients with transient ischemic attack, other non-stroke diagnoses, including thrombolysed stroke mimics, and people aged under 18 years were excluded. For any given individual patient, only the initial admission during the study period was counted as an index event; any subsequent admissions were considered outcome events.

#### Data collection:

Baseline data included patient demographics, vascular risk factors, pre-morbid level of function, employment status, domiciliary information, disability at hospital admission, arrival mode, arrival time from symptom onset, and stroke characteristics. Ethnicity was determined by self-identification. Post-admission data included in-hospital interventions and services, investigations, and therapies up to three months post admission, follow-up appointments up to 12 months, and outcome variables as described below. All patients were invited at three months to consent to further follow-up assessments at six and 12 months until a pre-set centre sample size target was reached.

#### Outcomes:

Main outcome measure: modified Rankin Scale (mRS) score at 3 months using an ordinal shift analysis.<sup>10</sup> Additional post stroke outcomes assessed were mRS shift analysis at 6 and 12 months; dichotomised mRS into favourable outcome (mRS=0-2) and unfavourable outcome (mRS=3-6); EuroQol 5-dimension, 3-level health-related quality of life questionnaire (EQ-5D-3L) scores; stroke recurrence; vascular events; readmission; and death at 3, 6 and 12 months.

Stroke care access measures: stroke thrombolysis and endovascular thrombectomy including associated time delays both pre-and in-hospital, acute stroke unit care, timely assessment by key members of an inter-disciplinary stroke team, relevant investigations to determine stroke aetiology, early mobilisation within 48 hours, swallow assessment within six and 24 hours, guideline based deep vein thrombosis prophylaxis, early prescription of anti-thrombotics, prescription of best medical management (tailored to stroke diagnosis and cause) by time of discharge, timely access to and therapist contact time during inpatient and community rehabilitation.

#### Data analysis:

All data were analysed in Stata/IC 16.0. We used descriptive statistics to summarise patient baseline characteristics using proportions for dichotomous, means and standard deviations for continuous, and medians and interquartile ranges for non-normally distributed continuous variables. We used Pearson's chi-squared test to compare dichotomous, t-test for normally distributed continuous, and Wilcoxon rank-sum test for non-normally distributed continuous baseline variables between hospital locations. Logistic regression, ordinal logistic regression (including mRS 'shift analysis') and linear regression were used to assess associations between hospital geographic location and dichotomous, ordinal and continuous outcomes, respectively, checking for normal distribution of the residuals. We initially conducted univariable analyses for all outcome variables. Multivariable models were controlled for known confounders, including age, ethnicity, stroke severity, stroke type, and pre-morbid level of function. Baseline characteristics that differed between groups by  $p < 0.1$  were also included in the multivariable models. For specific service access outcomes, we included additional variables known to affect intervention access that are outside the control of the hospital service such as hospital arrival time and mode when considering reperfusion therapy access. We then backward eliminated covariates starting with differences in baseline characteristics, followed by specific covariates added for the model in question, and finishing with known confounders. We eliminated covariates only if the effect on odds ratio was  $< 0.1$  and model fit was either improved or unaffected. In general, we aimed for the lowest number of covariates and best model fit without removing covariates that significantly affected the overall result. We checked for interaction effects between hospital location and ethnicity.

#### Standard protocol approvals, registrations and patient consents:

The Health Research Council of New Zealand (HRC 17/037) funded this study. The study received ethics approval from the Central Region Health and Disability Ethics Committee (17CEN164). Routine clinical patient data collection up to 3-months following discharge was classed as 'clinical audit' and the ethics committee waived the need for individual patients consent. We consented patients at their routine 3-month follow-up for subsequent follow-up as this was outside of usual care.

Data availability:

De-identified individual participant data, data dictionary, protocol, and consent forms can be requested via the corresponding author and will be available once all results from the study have been published assuming appropriate ethics approval is achieved.

## Results

Overall, 2,379 consecutive eligible patients (mean (standard deviation) age 75 (13.7); 51.2% male; 76.6% European; 11.5% Māori; 4.8% Pacific; 81.5% ischaemic and 12.3% haemorrhagic stroke) were included during the study period: 1,430 (60.1%) presented to an urban hospital and 949 (39.9%) to a non-urban hospital (Table 1).

### Impact of hospital location on outcomes

Patients treated at non-urban hospitals were more likely to score in a higher mRS (greater disability) category at three (aOR=1.28, 1.07-1.53), six (aOR=1.33, 1.07-1.65) and twelve months (aOR=1.31, 1.06-1.62) (Figure 1) and had lower odds of a dichotomised favourable outcome (mRS=0-2) at three months (aOR=0.72, 95% CI 0.56-0.93) and 6 months (aOR=0.71, 0.52-0.96). At twelve months the difference did not quite reach statistical significance (aOR=0.77, 0.57-1.04) (Figure 2).

Patients in non-urban hospitals had greater odds of recurrent vascular events at six months (aOR=1.87, 1.06-3.27) and twelve months (aOR=1.65, 1.09-2.52) (Figure 2) and higher odds of recurrent stroke at 12 months (aOR=1.94, 1.14-3.29). Patients treated at non-urban hospitals also had higher odds of death at all three time points, however, there was no significant difference in hospital readmission at any of the three time points.

For quality of life, measured using the EQ-5D-3L, patients treated at non-urban hospitals had a greater odds of reporting difficulties with their mobility at three months (aOR=1.58, 1.19-2.10) and pain at twelve months (aOR=1.41, 1.04-1.88) (Figure 3). The EQ-VAS score was significantly lower for patients treated at non-urban hospitals at three months (-3.21 (95% CI -5.85- -0.56)) and the summary index scores including deceased patients were significantly lower at all three time points for patients treated at non-urban hospitals (3 months: -0.05, -0.08- -0.02,  $p<0.0001$ ; 6 months: -0.05, -0.08- -0.02,  $p=0.003$ ; 12 months: (-0.04, -0.08- -0.01,  $p=0.01$ ).

#### Impact of hospital location on access to clinical guideline recommended stroke interventions

There was no difference in patients with ischaemic stroke treated with intravenous thrombolysis between non-urban hospitals, (14.2%) and urban hospitals (13.4%) (Figure 4). By contrast, access to endovascular thrombectomy at non-urban hospitals was lower (aOR=0.25, 0.13-0.49). Median onset to door time, door to needle time and onset to needle time were all significantly longer at non-urban hospitals (Table 2).

Other differences in non-urban hospitals included reduced care provided in an acute stroke unit (ASU) (aOR=0.60, 0.49-0.73), provision of antiplatelet medications within 24 hours of admission (aOR=0.72, 0.58-0.88), appropriate deep vein thrombosis prophylaxis (aOR=0.68,

0.56-0.83), provision of antiplatelet medications (aOR=0.50, 0.30-0.85) and statins (aOR=0.66, 0.49-0.89) as secondary vascular prevention prior to discharge (Figure 4).

Compared with those presenting to urban centres, patients treated at non-urban hospitals were less likely to access a minimum of one hour of physical therapy per working day during inpatient rehabilitation (aOR=0.55, 0.40-0.77) although access was sub-optimal in both groups (26.4% and 39.9% respectively). Patients treated at non-urban hospitals were also less likely to access community rehabilitation following hospital discharge (aOR=0.69, 0.56-0.84) and less likely to access it within seven days of discharge (aOR=0.59, 0.41-0.85) (Figure 5).

The odds of Māori patients being offered cultural support service while in hospital were higher in non-urban hospitals (aOR=1.87, 1.07-3.26). There was no difference found for Pacific patients being offered Pacific support services between urban and non-urban hospitals (aOR=1.02, 0.19-5.39).

## **Discussion**

This prospective observational study provides new evidence on the relationship between hospital location and stroke care access and outcome employing a uniquely comprehensive methodology that captures national consecutive stroke census data spanning care provision from hyperacute through to community care with follow-up to 12 months. We found that patients presenting to non-urban hospitals experience poorer post-stroke functional independence at 3, 6, and 12 months as well as higher stroke and vascular event recurrence and mortality at most time points. Hospital readmission rates were unaffected, and quality of life less profoundly affected, although the latter is likely due to survival bias because we found higher mortality rates in the non-urban centres compared to urban centres at the time

these outcomes were collected. In addition, we found inequitable access to many best-practice stroke care interventions for patients managed in non-urban hospitals.

Exploring differences in service access is important as it offers potential opportunities to focus service improvement efforts to achieve equitable outcomes despite geographic challenges. We found disparities in service access across many aspects of stroke care, some of which have previously been reported by others while others represent novel findings.<sup>6,8,11</sup> In contrast to other studies,<sup>6,7,9</sup> we found equal access to intravenous thrombolysis regardless of geography. A recent study from Australia reported a significant disparity in thrombolysis rates between urban (12.7%) and rural (7.5%) hospitals.<sup>9</sup> Equitable access in New Zealand is likely due to advanced telestroke networks and a mandatory national reperfusion register implemented in 2015 with quarterly central reporting.<sup>12,13</sup> However, endovascular thrombectomy remains less accessible in non-urban settings. A New Zealand-wide service improvement programme has just been approved to address this.<sup>14</sup>

Two prior large international studies found no difference in prescriptions for secondary vascular prevention medications by geography.<sup>8,15</sup> Our study found fewer prescriptions of antiplatelet agents and statins in non-urban hospitals, along with reduced access to ASU care, DVT prophylaxis, and carotid imaging. These areas present further opportunities to improve patient care to achieve better outcomes. It is important to note that many assessed interventions were equally accessed at non-urban centres indicating that equity is achievable. Our study provides guidance to stroke teams where to focus their improvement efforts.

In contrast to previous studies,<sup>8,16</sup> we found equal access to inpatient rehabilitation facilities across the country. However, a significant disparity in the amount of therapy patients receive



in non-urban hospitals was observed and the overall intensity of therapy across the country is very low. Research has shown a dose-dependent relationship between therapy and functional recovery following stroke.<sup>17</sup> This study has shown that services are currently falling well short of the recommended two hour daily physical therapy minimum,<sup>18</sup> regardless of geographical location, raising concerns as to how much benefit patients are actually receiving from their rehabilitation. The New Zealand National Stroke Network recently published a rehabilitation strategy and action plan to address this issue and this study provides further guidance directing these efforts to focus on increasing intensity of therapy and access to community rehabilitation services.<sup>19,20</sup>

Non-urban hospitals performed better than urban hospitals in providing in-hospital cultural support for indigenous Māori patients. In New Zealand and other bi- and multi-cultural countries, the provision of culturally responsive stroke care is crucial, involving the integration of cultural practices, values, and concepts into service delivery.<sup>3</sup> Māori have identified a lack of cultural concordance as a barrier to accessing health care.<sup>21</sup> New Zealand urban hospitals could benefit from understanding how non-urban centres are enhancing access to cultural support and culturally appropriate care for Māori patients. Addressing such barriers is of great importance as Māori, much like many other marginalised indigenous populations around the globe, experience overall worse health outcomes, generally attributed to the consequences of longstanding, entrenched structural inequities linked to a history of colonisation.<sup>22,23</sup> As part of our wider research programme we have recently reported and discussed in much greater detail issues faced by Māori people with stroke, which include not only significantly worse stroke outcomes, but also poorer access to several key stroke interventions.<sup>24</sup> Results of the present study, which focussed on geographic inequities, controlled for ethnicity confirming that ethnicity alone cannot explain the geographic

inequities we have identified. Although, given that Māori often reside rurally they will frequently face both ethnic and geographic inequities.

Service improvements to reduce geographic inequities may involve targeted education and resource investment to increase the number of stroke experts in non-urban centres. However, achieving optimal care in small general hospital settings may remain challenging considering potential financial inefficiencies, disincentives, and recruitment challenges. Alternatively, centralisation of stroke services could be considered. Such ‘hub and spoke’ models have been successfully used in the United Kingdom, with reduced mortality rates, reduced hospital length of stay and improved patient access to important stroke interventions.<sup>25,26</sup> Some patients, however, may still prefer being treated ‘close to home’ especially where the distance to a tertiary centre is several hours by car. Qualitative research undertaken as part of this wider study will help provide insights into patient preferences as to whether further centralisation of stroke services should be explored. From a health care modelling perspective, keeping patients ‘close to home’ has the added advantage of ensuring sufficient case volumes remain in regional hospitals to maintain overall viability of non-urban health care facilities. This may be more important in low population density countries such as New Zealand, Australia, and Scotland where disestablishing smaller community hospitals might mean hours of patient travel times for routine hospital care. In these settings a ‘virtual centralisation’ through telehealth systems as part of strong regional clinical networks extending into the rehabilitation and community phases of care may offer the best opportunities for widespread improvement. We have demonstrated that such collaborative regional clinical networks along with mandated nationwide quality initiatives can achieve geographic equity in thrombolysis access.<sup>12,13</sup>

Limitations of this study include its observational nature and associated risk of potential residual confounding, particularly since some baseline characteristics differed between study groups. The difference in ethnicity by hospital location is not unexpected, as nearly 80% of Pacific peoples live in the Auckland and Wellington urban regions<sup>27</sup> and a higher proportion of Māori live in non-urban areas compared with the total New Zealand population.<sup>28</sup> This may also explain observed differences in stroke risk factors given that previous research has shown that Māori have higher rates of obesity, smoking, hypertension and diabetes mellitus.<sup>29–31</sup> However, we did not find a significant interaction effect between hospital location and ethnicity and all models were adjusted for ethnicity and other potential confounders including any differences in baseline characteristics. We were unable to capture socioeconomic status in this study, however, the New Zealand health system provides universal free public hospital health coverage, thus, finances are likely less of an access barrier than in other health systems. Finally, in light of the multiple comparisons assessing access to various stroke interventions, these findings should be interpreted with a degree of caution and viewed primarily as exploratory, especially where confidence intervals are large and/or only trends were identified.

Strengths of this study are the inclusion of all New Zealand acute stroke services and consecutive patient recruitment allowing for a census data set eliminating selection bias while offering excellent representation from both urban and non-urban hospitals. Data collection across the care continuum including post-discharge community care and 12-month follow-up, achieved in 91.5%, represent further key strengths. Previous research assessing the effect of hospital location has focussed primarily on the acute stroke phase of care and association with early patient outcomes reporting conflicting results.<sup>6,8,32</sup> Looking at the whole continuum of care and outcomes up to 12 months post stroke has allowed us to also explore differences

in access to inpatient rehabilitation and community care which are likely relevant to patients and may impact longer term outcomes.

In conclusion, patients treated in non-urban hospitals experience poorer outcomes in terms of functional independence, death, recurrent strokes, and vascular events and have poorer access to best practice stroke care both in hospital and after discharge. This research highlights specific areas for targeted improvement, that will likely need to involve new models of care, in addition to focussed resource investment and education. A full health economics analysis to determine additional resource investment requirements and cost-utility is underway.

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**Table 1: Patient baseline characteristics**

	Urban	Non-urban	p-value				
Number, n(%)	1430 (60.1)	949 (39.9)		Ischaemic stroke location, n(%)			0.15
Age, Mean (SD)	74.6 (14.2)	75.5 (12.8)	0.46	Anterior circulation	787 (68.1)	489 (70.0)	
Sex, male, n(%)	721 (50.4)	498 (52.5)	0.33	Posterior circulation	295 (25.5)	164 (23.5)	
Ethnicity, n(%)			<0.001	Spinal cord	5 (0.4)	0 (0.0)	
European	1066 (74.6)	757 (79.8)		Other	21 (1.8)	8 (1.1)	
Māori	115 (8.0)	158 (16.7)		Unknown	48 (4.2)	38 (5.4)	
Pacific	105 (7.3)	9 (0.95)		Ischaemic stroke cause, n(%)			0.05
Asian	103 (7.2)	12 (1.3)		Cardioembolic – atrial	389 (33.1)	238 (31.4)	
Other	41 (2.9)	13 (1.4)		fibrillation	7 (0.6)	2 (0.3)	
Primary diagnosis, n(%)			<0.001	Cardioembolic – non-atrial	64 (5.4)	32 (4.2)	
Ischaemic stroke	1198 (83.8)	739 (78.0)		fibrillation	17 (1.5)	8 (1.1)	
Haemorrhagic stroke	188 (13.2)	104 (11.0)		Carotid stenosis	173 (14.7)	104 (13.7)	
Stroke not specified	34 (2.4)	82 (8.7)		Vertebrobasilar stenosis	21 (1.8)	12 (1.6)	
Other	10 (0.7)	22 (2.3)		Small vessel	55 (4.7)	25 (3.3)	
				Intracranial stenosis	427 (36.3)	331 (43.6)	
				Other	23 (2.0)	7 (0.9)	

SOL=space occupying lesion; AVM=arteriovenous malformation; IQR=interquartile range; TIA=transient ischaemic attack; ICH=intracerebral haemorrhage; GI=gastrointestinal; mRS=modified Rankin Scale; GCS=Glasgow Coma Scale; MRC=Motor Research Council Scale for muscle strength ranging from 0=no visible contraction to 5=normal power

Unknown			
Dissection			
Haemorrhagic stroke location, n(%)			0.006
Lobar	83 (45.6)	53 (55.8)	
Deep	86 (47.3)	28 (29.5)	
Other	9 (5.0)	13 (13.7)	
Unknown	4 (2.2)	1 (1.1)	

Haemorrhagic stroke cause, n(%)			0.12
Hypertensive	98 (54.4)	49 (51.0)	
Anticoagulation	7 (3.9)	6 (6.3)	
Amyloid Angiopathy	10 (5.6)	5 (5.2)	
Haemorrhagic transformation	29 (16.1)	7 (7.3)	
Underlying	4 (2.2)	2 (2.1)	

SOL/AVM/aneurysm	0 (0.0)	1 (1.0)	
Trauma	7 (3.9)	2 (2.1)	
Other	25 (13.9)	24 (25.0)	
Unknown			
Risk factors, n(%)			
Prior stroke	307 (21.7)	208 (22.2)	0.22
Prior TIA	163 (11.5)	140 (15.0)	<0.0001
Carotid stenosis	113 (8.0)	67 (7.4)	<0.0001
Hypertension	1027 (72.4)	668 (70.8)	0.08
Diabetes	345 (24.4)	226 (24.0)	0.03
Dyslipidaemia	558 (39.5)	440 (47.4)	<0.0001
Atrial fibrillation	478 (33.7)	329 (35.3)	0.001
Smoker	155 (11.0)	132 (14.1)	<0.0001
Ischaemic heart disease	359 (25.4)	216 (23.2)	<0.0001
Rheumatic heart disease	24 (1.7)	16 (1.7)	0.89
Family history of stroke	80 (5.7)	81 (8.7)	<0.0001

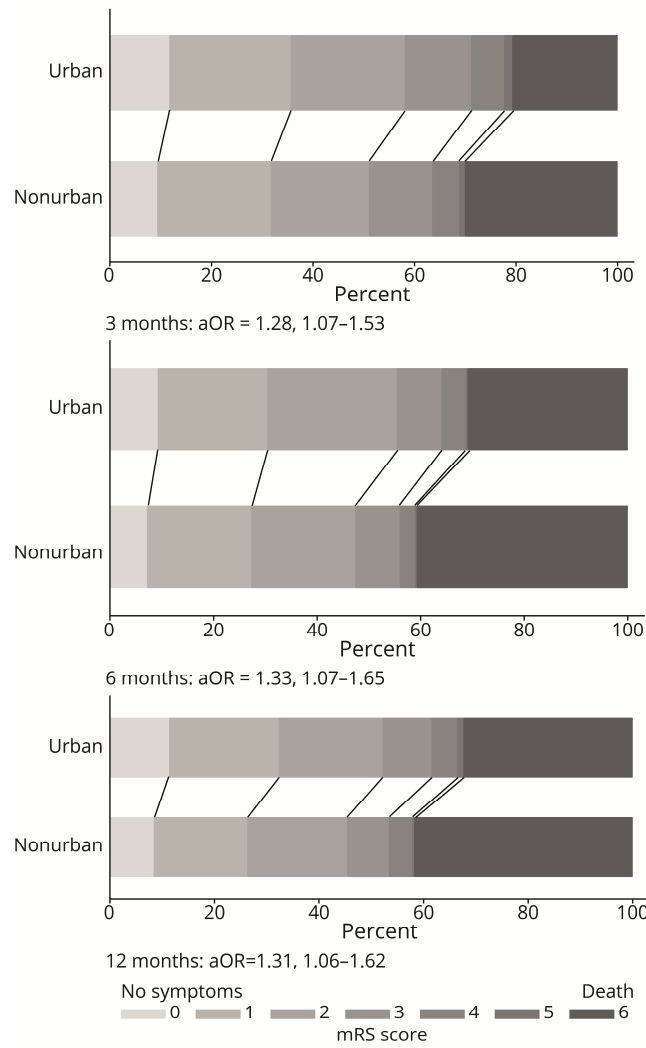
SOL=space occupying lesion; AVM=arteriovenous malformation; IQR=interquartile range; TIA=transient ischaemic attack; ICH=intracerebral haemorrhage; GI=gastrointestinal; mRS=modified Rankin Scale; GCS=Glasgow Coma Scale; MRC=Motor Research Council Scale for muscle strength ranging from 0=no visible contraction to 5=normal power

Initial observations, median (IQR)	7 (5.8-8.7)	7.1 (6.1-9.2)	0.08
Blood glucose	160 (140-183)	160 (140-182)	0.58
Systolic blood pressure			
Pre-stroke situation, n(%)			
Pre-stroke independence (mRS 0-2)	1233 (86.8)	807 (86.7)	0.95
Employed	309 (21.7)	56 (16.6)	0.002
Living situation			
Home alone	386 (27.0)	295 (31.2)	0.02
Home with others	921 (64.5)	570 (60.2)	
Residential care	101 (7.1)	77 (8.1)	
Other	21 (1.5)	5 (0.5)	
Level of disability on arrival n(%)			
GCS verbal <5	503 (35.3)	355 (37.5)	0.27
	786 (55.1)	546 (57.8)	0.20

Requires assistance to walk	479 (33.6)	392 (41.4)	<0.001
Upper limbs MRC <3/5			

SOL=space occupying lesion; AVM=arteriovenous malformation; IQR=interquartile range; TIA=transient ischaemic attack; ICH=intracerebral haemorrhage; GI=gastrointestinal; mRS=modified Rankin Scale; GCS=Glasgow Coma Scale; MRC=Motor Research Council Scale for muscle strength ranging from 0=no visible contraction to 5=normal power

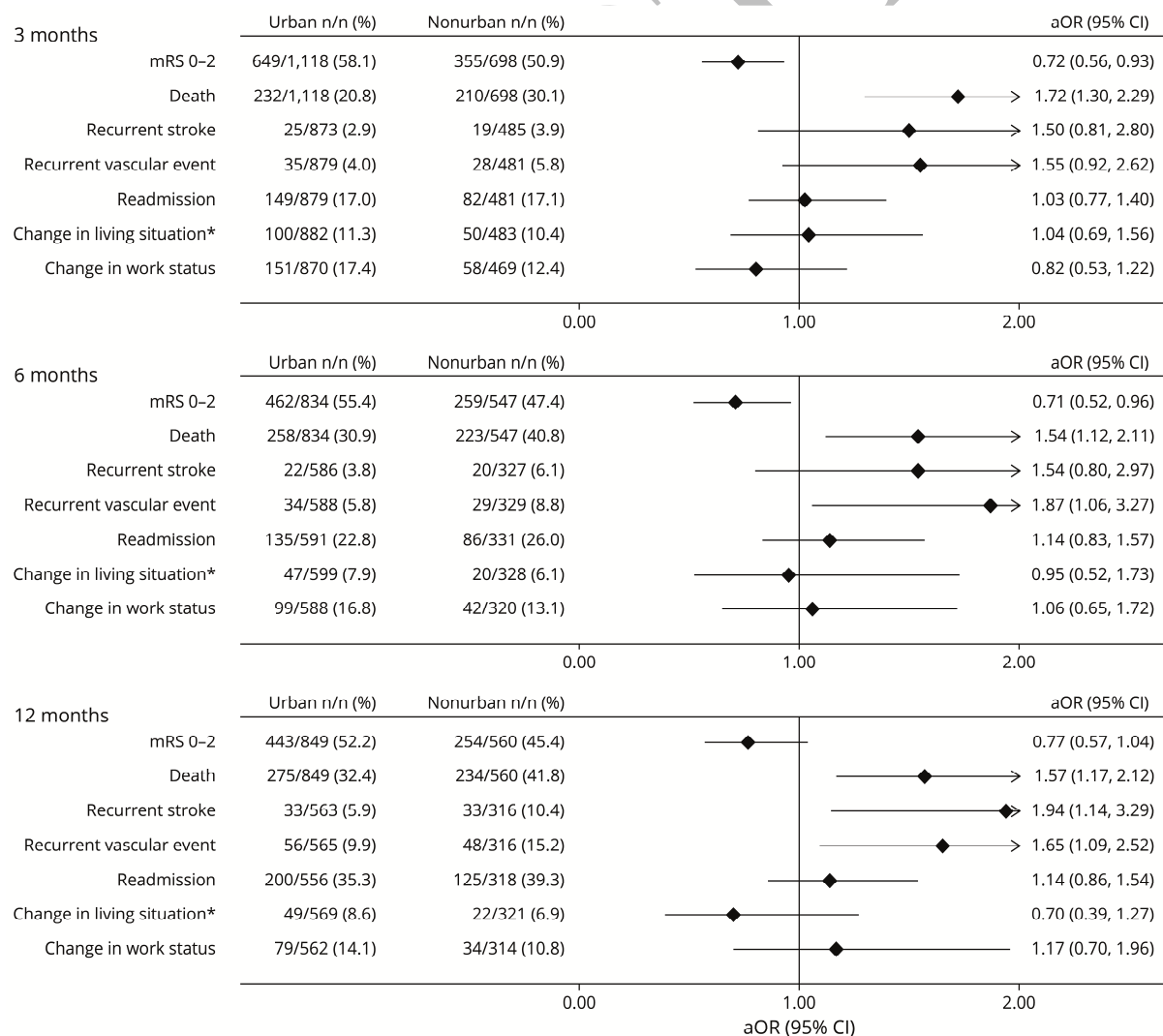
**Figure 1: mRS shift analysis at 3, 6 and 12 months**





**Figure 2: Urban versus non-urban comprehensive stroke outcomes**

95% CI= 95% confidence interval; aOR = adjusted odds ratio (all outcomes were adjusted for pre-morbid level independence, age, sex, ethnicity, stroke severity, and baseline characteristic differences of  $p < 0.1$ . Covariates were backward eliminated if removal did not substantially affect the odds ratio aiming to minimise number of covariates and optimise model fit); mRS=modified Rankin Scale; \*‘Change in living situation’ refers to a new move to a care facility, move from independent living to a family member or other carer home, or a family member or carer moving into the patient’s home to provide care.



**Figure 3: Urban vs non-urban quality of life (EQ-5D-3L) – reporting any problems**

95% CI= 95% confidence interval; aOR = adjusted odds ratio (all outcomes were adjusted for pre-morbid level independence, age, ethnicity, stroke severity, and baseline characteristic differences of  $p < 0.1$ . Covariates were backward eliminated if removal did not substantially affect the odds ratio aiming to minimise number of covariates and optimise model fit).

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**Table 2: Hyperacute time delays**

	Urban	Non-urban	aOR (95% CI)
Symptom onset to hospital arrival time < 4hours, n/n(%)	602/1404 (42.9)	418/918 (45.5)	0.91(0.74-1.13)
Symptom onset to hospital arrival time < 24hours, n/n(%)	1062/1404 (75.6)	722/918 (78.7)	1.08 (0.87-1.34)
Arrive by emergency ambulance/helicopter, n/n(%)	698/1374 (50.8)	552/933 (59.2)	1.38 (1.14-1.66)
			p-value
Symptom onset to arrival time (mins), median (IQR)	77.5 (48-128)	103.5 (53.5-195.5)	0.005
Arrival to CT time (mins), median (IQR)	23 (16-36)	29.5 (16-49)	0.06
Arrival to needle time (mins), median (IQR)	53 (38-87)	66 (47.5-95)	0.02
Symptom onset to needle time (mins), median (IQR)	141 (106-193)	161.5 (120.5-205)	0.01

95% CI=95% confidence interval; aOR=adjusted odds ratio where models included pre-morbid level independence, age, sex, ethnicity, stroke severity, baseline characteristic differences of  $p < 0.1$ . Covariates backward eliminated unless removal substantially affected odds ratio aiming to minimise number of covariates and optimise model fit.

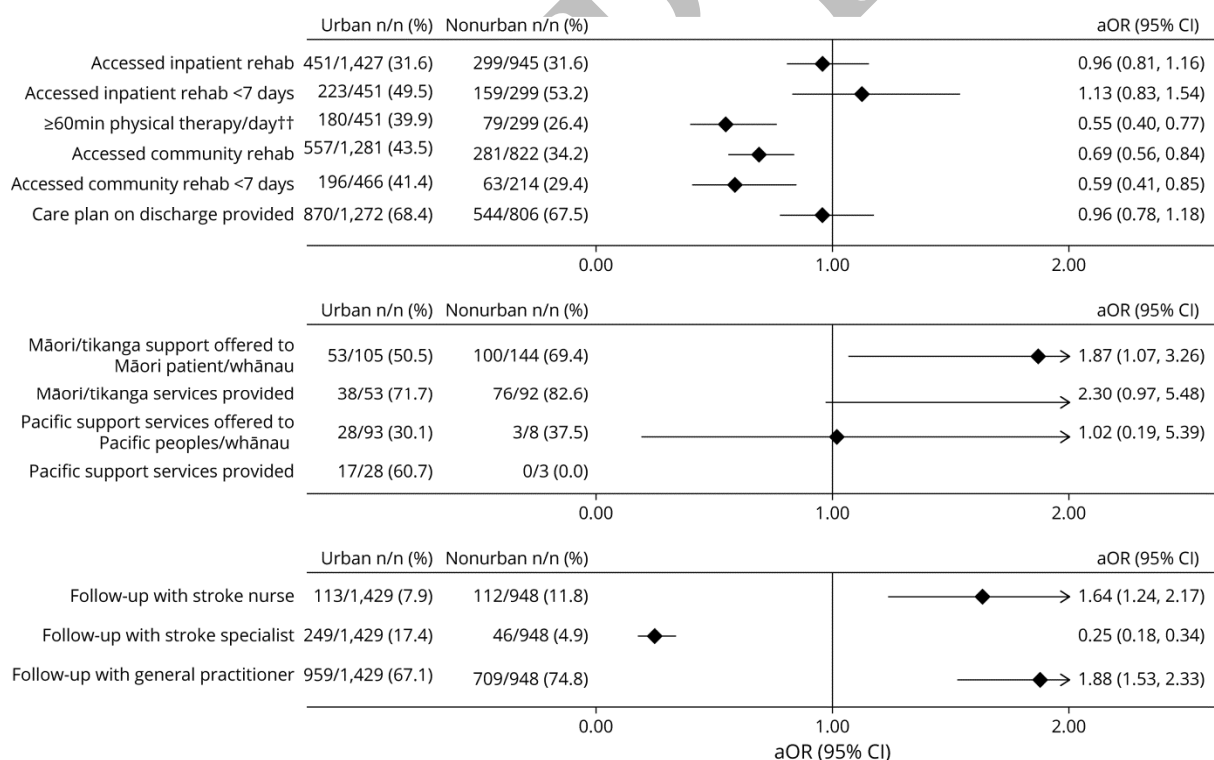
#### **Figure 4: Urban versus non-urban access to stroke interventions/care**

95% CI=95% confidence interval; aOR=adjusted odds ratio (all outcomes were adjusted for pre-morbid level of independence, age, sex, ethnicity, stroke severity, baseline characteristic differences of  $p < 0.1$ , and intervention specific covariates such as time delay to reach hospital, mode of transport for reperfusion therapies and as palliation within 24 hours for early mobilisation and allied health input. Covariates were backward eliminated unless removal substantially affected odds ratio aiming to minimise number of covariates and optimise model fit). ASU=acute stroke unit; DVT=deep vein thrombosis; IDT=interdisciplinary team; Stroke nurse specialist assessment refers to a stroke clinical nurse specialist review of the patient on the ward while an inpatient; BMT='best medical therapy' refers to antiplatelet(s), statins, and anti-hypertensives for non-cardioembolic ischaemic stroke patients, anti-hypertensives for ICH patients attributed to hypertension, and anticoagulation for patients with cardioembolic stroke unless any contraindications documented; \*Denominator for these analyses consists of only those patients with a primary diagnosis of ischaemic stroke; †'Reperused of those eligible' refers to patients undergoing thrombolysis and/or thrombectomy among those who presented within the require time window and did not have appropriate exclusion criteria; ‡'Mobilised' refers to any 'out of bed activity'; \*\*Analysis limited to current smokers at the time of presentation. §The higher rate of telemetry at non-urban hospitals is likely related to one of the largest New Zealand tertiary centre's preference to perform serial 12-lead ECGs for AF detection

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### Figure 5: Urban versus non-urban access to rehabilitation and follow-up care

95% CI=95% confidence interval; aOR=adjusted odds ratio (all outcomes were adjusted for pre-morbid level of independence, age, sex, ethnicity, stroke severity, baseline characteristic differences of  $p < 0.1$ , and intervention specific covariates such as time delay to reach hospital, mode of transport for reperfusion therapies and as palliation within 24 hours for early mobilisation and allied health input. Covariates were backward eliminated unless removal substantially affected odds ratio aiming to minimise number of covariates and optimise model fit). Tikanga=Māori customary practices; whānau=immediate or extended family in Māori language; Follow-up with stroke nurse refers to post-discharge follow-up appointment with a stroke clinical nurse ††week days only



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