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Assessment and selection for rehabilitation following acute stroke: a prospective cohort study in Queensland, Australia.

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Abstract:

Assessment and selection for rehabilitation following acute stroke: a prospective cohort study in Queensland, Australia.

Objective To describe current practice and investigate factors associated with selection for rehabilitation following acute stroke.

Design Prospective observational cohort study.

Setting Seven public hospitals in Queensland, Australia.

Subjects Consecutive patients surviving acute stroke.

Measures Rehabilitation selection processes: assessment for rehabilitation needs, referral for rehabilitation, receipt of rehabilitation. Functional impairment following stroke: modified Rankin Scale (mRS).

Results We recruited 504 patients, median age 73 years (IQR 62, 82) between July 2016 and January 2017. Of these, 90% (454/504) were assessed for rehabilitation needs, 76% (381/504) referred for rehabilitation, and 72% (363/504) received any rehabilitation. There was significant variation in all rehabilitation selection processes across sites ($p<0.05$). In multivariable analyses (Odds Ratio; 95% CI), stroke unit care (2.7; 1.1, 6.6) and post stroke functional impairment (severe stroke mRS 4-5: 10.9; 4.9, 24.6) were associated with receiving an assessment for rehabilitation. Receipt of rehabilitation was more likely following assessment (6.5; 2.9, 14.6) but less likely in patients with dementia (0.2; 0.1, 0.9), end-stage medical conditions (0.4; 0.2, 0.8) or ischaemic stroke (0.4; 0.1, 0.9). The odds of receiving rehabilitation increased with greater impairment: Odds Ratio 3.0 (1.5, 4.9) for mRS 2-3 and 12.5 (6.5, 24.3) for mRS 4-5. Among patients with mild-moderate impairment (mRS 2-3), 39/117 (33%) received no rehabilitation.

Conclusions There was significant inter-site variation in rehabilitation selection processes. The major factors influencing rehabilitation access were assessment for rehabilitation needs, co-morbidities and post stroke functional impairment. Gaps in access to rehabilitation were found in those with mild to moderate functional impairment.

Title: Assessment and selection for rehabilitation following acute stroke: a prospective cohort study in Queensland, Australia.

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Conclusions

There was significant inter-site variation in rehabilitation selection processes. The major factors influencing rehabilitation access were assessment for rehabilitation needs, co-

morbidities and post stroke functional impairment. Gaps in access to rehabilitation were found in those with mild to moderate functional impairment.

Introduction

Rehabilitation can maximise functional outcomes for patients with impairments and participation restriction following acute stroke.¹ In guidelines from across the world it is recommended that all patients receive early assessment²⁻⁴ and commencement of rehabilitation within a stroke unit.^{2, 3, 5} This is because early and coordinated rehabilitation is one of the major factors implicated in the positive effects of stroke units.⁶

Comprehensive stroke units which provide care from acute management until the end of inpatient rehabilitation are rare in Australia and most rehabilitation is provided via subsequent transfer to dedicated rehabilitation services. The median acute length of stay for stroke patients in Australian acute stroke units is currently five days,⁷ therefore decisions regarding rehabilitation need to be made early. A shorter length of stay was associated with a lower chance of receiving an assessment for rehabilitation in the American Get With The Guidelines program.⁸

Processes to access rehabilitation vary widely across health systems, but within Australia they typically include initial assessment identifying rehabilitation needs, subsequent referral to rehabilitation providers, and assessment and acceptance by rehabilitation providers. This process produces potential for disconnection in a critical component of stroke care, the evidence base for which is founded on organisation of care.⁶

Against this background, there is evidence of highly variable practice in assessment and selection for rehabilitation both between sites⁹⁻¹¹ and across different countries.¹² Further, there are very little data available on access to rehabilitation in outpatient or community settings. To promote efficient and equitable access to rehabilitation after stroke it is essential to understand the processes and factors that influence who is selected for rehabilitation.

We aimed to: determine current clinical practice and processes regarding patient selection for, and access to, rehabilitation following acute stroke; and investigate patient and system factors associated with selection for rehabilitation.

Methods

We performed a prospective cohort study of consecutive stroke patients in public hospitals in Queensland, Australia between July 2016 and January 2017. Eight out of 20 Queensland public hospitals with acute stroke units were purposively selected to provide a representative sample of the types of hospital admitting acute stroke patients across this state of Australia. Two of the sites were metropolitan comprehensive stroke units providing a full range of stroke services; three were referral hubs in regional areas, and three were small metropolitan primary stroke units linked to one of the comprehensive units. Average stroke admissions per annum varied from 100 to 550 patients. Further details are presented in Supplementary Table 1. The study was approved by The Prince Charles Hospital Human Research Ethics committee (HREC/16/QPCH/37), the Queensland Government under the Public Health Act 2005, and the Australian Stroke Clinical Registry and Australian Stroke Data Tool governance committees. Funding support was provided by the Clinical Excellence Division, Queensland Department of Health.

We recruited up to 100 consecutive patients with an acute stroke who survived to the end of the acute care episode from each centre with the aim to include all survivors of stroke including those with severe and terminal co-morbidities. Inclusion criteria were: admission to hospital for acute stroke defined by International Disease Classification version 10 discharge code of I61, I62.9, I63 or I64; 18 years of age or older; and able to provide consent, or have consent provided by an appropriate substitute decision maker. Residents from outside of Queensland were excluded to enable mapping of subsequent rehabilitation services.

At each site a senior physiotherapist or occupational therapist identified patients with acute stroke prospectively from the acute stroke unit and medical admission lists, supplemented by retrospective review of hospital coding data following discharge. Where possible, recruitment of patients was conducted during their acute admission. Patients who were missed during the acute admission, including those identified from retrospective review of

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coded hospital admissions data, were contacted by mail to request participation in the study. Written informed consent was obtained for collection of data from medical records in the acute and any subsequent rehabilitation episode in the 6 months following their stroke, and for linkage with the Australian Stroke Clinical Registry.¹³ Where capacity to provide consent was impaired due to cognitive or communication impairments, consent was provided by the legal health attorney under Queensland law.

Data were entered onto a specific program developed on the Australian Stroke Data Tool¹⁴ which is an integrated online secure data collection and management system for stroke. It hosts a number of quality improvement and research databases and utilises standardised definitions to ensure consistency in data collection.¹⁵

Data were extracted by the trained senior occupational and physio-therapist staff from hospital medical records for the acute stroke episode to obtain demographic, clinical, and rehabilitation selection process details. Regular meetings were held to ensure consistency of data collection and resolve uncertainty, with reference to the data dictionary. Nursing, allied health and medical records were used to document presence of impairments (e.g. motor, cognitive, dysphagia) and allied health assessments (physiotherapy, occupational therapy, speech pathology, social work, dietician, psychologist). Premorbid conditions which may impact on rehabilitation suitability or outcomes were recorded including dementia, co-morbidities and functional status.¹⁶ Comorbidities other than dementia which also may impact on rehabilitation selection were termed “end-stage medical conditions” and defined as: conditions which substantially limit ability to participate in rehabilitation, impact on prognosis (estimated less than 3-6 months as estimated by the medical team) or alter stroke management decisions to palliative intent (e.g. severe chronic obstructive pulmonary disease or terminal malignancy).

Measures and definitions

Measures of rehabilitation selection processes used in this study were: assessment for rehabilitation needs, referral for rehabilitation, and receipt of rehabilitation. **Assessment for rehabilitation needs** was defined as documentation in the medical record of specific assessment regarding rehabilitation needs and suitability and was not inferred from presence of a referral to a rehabilitation provider. The person or team making the assessment, and

whether rehabilitation needs were identified or not was recorded. **Referral for rehabilitation** was defined as any documentation of referral of the patient to a rehabilitation provider, including on a referral form. Following discharge, all rehabilitation providers were contacted to request details regarding whether rehabilitation was received by these patients.

Receipt of rehabilitation was defined as having at least one face to face occasion of service by an allied health professional within a rehabilitation service. For inpatient rehabilitation, only administratively specified rehabilitation episodes were recorded which in Queensland requires evidence of rehabilitation by defined multidisciplinary teams, evidence of regular team meetings, and submission of Functional Independence Measure scores. **Acute length of stay** was defined according to standard Department of Health reporting procedures, ending on discharge, or commencement of a formal rehabilitation episode.

The modified Rankin Scale (mRS whereby a score of 0 indicates no symptoms or disability and score of 5 indicates severe disability and dependence)¹⁷ was used to indicate functional level pre and post stroke, and as a proxy for stroke severity on day 3 of admission or at discharge, whichever was earlier. Project staff rated patients directly where possible, or estimated from documented allied health, nursing and medical assessments for patients not recruited during their acute admission, using a standardised decision support tool.¹⁵

Statistical analysis

We used descriptive analyses to compare patient characteristics and processes of care by the subgroups of interest. Univariable analyses were performed using the Pearson χ^2 tests for categorical variables and the Wilcoxon Mann–Whitney rank-sum test for continuous variables. All tests were 2-sided with P-value set at less than 0.05.

Multilevel, multivariable analyses were performed using logistic regression with level defined as hospital to account for correlations of processes and among patients within individual hospitals. We used a stepwise approach to develop parsimonious, but complementary models with assessment for rehabilitation needs, referral to rehabilitation providers, and receipt of rehabilitation as the dependent variables. We initially performed univariable logistic regressions with all clinical, demographic and process measures collected to determine which factors were associated with receiving rehabilitation selection processes. Variables with P-values > 0.2 were included in an initial multivariable model. Manual,

backward stepwise regression was then performed, sequentially removing variables with the largest P-values above 0.05. A set of a priori variables known to be associated with outcomes of interest (age, pre-stroke functional level, dementia, post stroke functional level)¹⁶ were included in the model regardless of their statistical significance. The effect of variable removal at each stage was monitored using the Akaike Information Criterion and Bayesian Information Criterion and sequential removal ceased when there was no longer a downward trend in either.²³ Likelihood ratios were also calculated to check goodness of fit. Once the models were finalised receiver operator characteristic curves were generated and the area under them calculated. Multivariable results were reported as adjusted Odds Ratios (OR) with 95% confidence intervals. Data were analysed using STATA V 14.2 (Statacorp, College Station, 2018 USA).

Results

Between July 2016 and January 2017, 746 patients were screened for eligibility and 511 patients were recruited. Seven participants from one small metropolitan site (100 stroke admissions per year) were withdrawn from the study due to recruitment difficulties leaving 504 participants in the study (Figure 1). Baseline characteristics of the participants are summarised in Table 1 with further detail in Supplementary Table 2. Patient age, sex, living arrangements and type of stroke were similar across sites, but there was variation in the presence of comorbidities, and pre-morbid dependency. The majority of participants (n=346, 69%) were functionally dependent on day three post stroke (mRS 3-5), and this was consistent across sites (p=0.2). Median acute length of stay was 5 days (IQR 3, 9) and varied across sites from 3 (IQR 2, 5) to 7 (IQR 4, 12) days (p<0.001).

The flow through rehabilitation selection processes is depicted in Figure 1. There was significant variation between sites in assessment for rehabilitation needs (range 76 - 100%, p<0.001). Assessments were performed by the acute stroke unit multidisciplinary team in 294 (68%), rehabilitation providers 116 (26%), acute medical staff 22 (5%), and others on 5 (1%) occasions. Of those assessed for rehabilitation 384/454 (85%) were deemed to have rehabilitation needs, of whom 373 (97%) were referred for rehabilitation, and 342 (89%) received any rehabilitation. A standardised Australian assessment for rehabilitation tool²⁴ was used with 12 (3%) patients at one site.

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3 Patient factors significantly associated with greater chance of being assessed for
4 rehabilitation needs on univariable analysis included post stroke functional impairment (mRS
5 score), and presence of motor, cognitive, or communication impairments immediately
6 following stroke. Age, sex, premorbid function, co-morbidities and living arrangements were
7 not related to likelihood of assessment for rehabilitation (Table 1). Processes of care
8 associated with assessment for rehabilitation needs included admission to a stroke unit, and
9 assessment by allied health professionals (Table 2). Those not assessed had a shorter length
10 of stay (3.5 days, IQR 2,5) than those assessed for rehabilitation needs (5days IQR 3, 9;
11 $p=0.001$). In multivariable analysis, only stroke unit care and post stroke impairment
12 remained significant predictors of assessment for rehabilitation (Table 3). Functional
13 impairment post stroke and assessment for rehabilitation needs were the only factors
14 predictive of referral for rehabilitation in multivariable analysis (Table 3).

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17 In multivariable analysis, dementia, end stage medical conditions, and ischaemic stroke type
18 were associated with significantly lower odds of receipt of rehabilitation whereas higher post
19 stroke mRS score and rehabilitation needs assessment were associated with greater chance of
20 receiving rehabilitation (Table 3).

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23 Reasons for not receiving rehabilitation were documented in 104/141 (74%) patients, with
24 “return to premorbid function” in 82 (79%) despite the post stroke modified Rankin Scale
25 score being higher than the pre-stroke score in 38/82 (46%) (Figure 1).

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28 All rehabilitation selection processes and identification of rehabilitation needs were more
29 likely with increasing functional impairment (Table 4). One third (39/117) of those with a
30 post stroke mRS score of 2 or 3 did not receive rehabilitation, although 91/117 (78%) had
31 rehabilitation needs identified and 89/117 (76%) were referred for rehabilitation. Four (1%)
32 patients were discharged directly to residential aged care without a rehabilitation episode.

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35 The most common setting for initial rehabilitation was an inpatient unit: 203/504 (40%) of
36 all; and 203/363 (56%) of those receiving any rehabilitation. Inpatient rehabilitation was
37 more likely with greater post stroke functional impairment, whereas those with lesser
38 functional impairment were most likely to receive community rehabilitation (Supplementary
39 Table 3).

Discussion

The most consistent factor predicting assessment, referral, and subsequent receipt of rehabilitation in our cohort was the degree of early post stroke functional impairment. Although patients with marked functional dependence (mRS 4-5) were highly likely to receive rehabilitation (usually as an inpatient), our results demonstrate significant gaps in provision of rehabilitation for patients with intermediate levels of impairment. One third of those who were independently ambulant but had not regained ability to complete their usual activities (mRS 2), or basic self-care (mRS 3), did not receive any rehabilitation. Assessment for rehabilitation needs was the most significant modifiable system factor influencing access to rehabilitation with a 6 -fold greater adjusted odds of receiving rehabilitation if an assessment was performed. Although 90 percent of all patients received an assessment for rehabilitation needs, there was significant variation between sites in this practice (76-100%). Stroke survivors with ischaemic stroke, dementia and end stage medical comorbidities were consistently assessed and referred, but less likely to receive rehabilitation. Considering these factors within the context of different rehabilitation service configurations may assist in targeting efforts to improve equity in access to post stroke rehabilitation.

Limitations of our study include a lack of data on the influence of system constraints such as acute hospital length of stay pressures and rehabilitation bed availability on access to rehabilitation. We also did not collect data on additional patient factors which may affect decision making regarding rehabilitation including educational level, socio-economic advantage or carer status. Qualitative studies from both patient and clinician perspective are underway to further elucidate the influence of system constraints on the rehabilitation selection process.

It must be recognised that service configurations vary widely across different health systems and that our findings need to be related to local context. For example, assessment for rehabilitation needs was undertaken by the stroke unit multidisciplinary team in the majority of our cohort. The short acute length of stay in our cohort, therefore, was not an impediment to initial comprehensive multidisciplinary assessment, but may be in other settings which rely more heavily on external rehabilitation specialists to provide assessment services. In addition, definitions of rehabilitation may vary widely. We defined inpatient rehabilitation according to the local administrative requirements for funding of rehabilitation admissions

which meant that only multidisciplinary rehabilitation within stroke units and dedicated rehabilitation units were included. As this was an administratively defined “episode”, acute length of stay was separated from rehabilitation episodes within stroke units. That is, although a patient may not have changed physical location from a stroke unit, the type of care they received was classified differently to distinguish between acute care ending and sub-acute inpatient rehabilitation commencing.

It is possible that our sample is biased toward more severe stroke as the proportion of people with milder functional impairment on day three was relatively small. This group had shorter lengths of stay and may have been less often recruited to our study. A selection bias such as this, however, would be expected to lead to an over-estimation of rates of rehabilitation in patients with mild functional impairment as shorter length of stay was also associated with a reduced chance of receiving rehabilitation. Our sample is quite generalisable, with comprehensive case finding of all patients surviving acute stroke in a broad range of hospital types and locations across a wide geographical region. The withdrawal of one small metropolitan site is unlikely to have significant impact on the overall generalisability as two similar sites remained in the overall sample. Unlike most previous studies, we have systematically captured access to rehabilitation in community as well as inpatient sectors at any time within the first 6 months following stroke.

In our cohort, assessment for rehabilitation needs was much more common (90%) than in other multi-site Australian studies (59-63%),^{10, 11} but similar to the 90% reported in the United States ‘Get with the guidelines program’⁸ and 91% having agreed rehabilitation goals within five days in the United Kingdom National audit.²⁵ It may be significant that both of these reports come from systems participating in continual audit of processes with either public reporting or incentives. In Queensland, similar system drivers are present where incentives for stroke unit access have been linked to reporting of clinical indicators and assessment against national guidelines including early rehabilitation.¹³ The influence of admission to a stroke unit on assessment for rehabilitation has been previously reported⁸ and likely reflects greater organisation of care in stroke units. This supports the notion that system wide influences can lead to improved equity in rehabilitation selection. It is notable, however that there was very low uptake of a standardised assessment tool introduced in Australia in 2012 to “ensure fair and accountable decision making when assessing patients in acute care for stroke rehabilitation.”²⁴

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Assessment is only the first step in a path designed to ultimately provide rehabilitation to those requiring it and, consistent with our results, others have reported significant gaps between the proportion of those assessed as having rehabilitation needs being referred, or accessing rehabilitation.^{10, 18} Authors of previous studies, however, have focused on the more severely impaired patients being denied access to rehabilitation, predominantly related to service access constraints and early prediction of final discharge destination to residential care.^{12, 18, 26, 27} In contrast, we found that the largest access gap was in the group with less severe stroke. Patients who are functionally independent following acute stroke often have subsequent problems with cognition, communication, mood, participation in leisure and work activities, and basic and instrumental activities of daily living,²⁸⁻³⁰ many of which may be improved with rehabilitation therapy.²⁹ This highlights a gap in our system and indicates a need to provide access to services such as coordinated rehabilitation in the home, which is effective in those with mild to moderate disability post stroke.³¹

We found 85% of all patients assessed were deemed to have rehabilitation needs, similar to 75% in an Australian national audit¹⁰, and findings by Lynch et al¹¹ that 78% of those assessed were recommended for rehabilitation. These figures, however, are based on initial clinician assessment of rehabilitation need, and do not indicate optimal rehabilitation setting (inpatient / home / outpatient), degree of benefit, or resource constraints of either health system or patient. The rate of 40% receiving inpatient rehabilitation in our study compares favourably with a Canadian study which found 37% of acute stroke patient were candidates for inpatient rehabilitation.¹⁸ Reported access to inpatient rehabilitation varies widely in different countries from 13% in Sweden to 57% in Israel.¹² There is a paucity of data regarding availability and access to non-admitted forms of rehabilitation following stroke. Together with the gaps we have identified in rehabilitation access in patients with mild to moderate impairment post stroke, this indicates a need for further work to establish benchmarks and system requirements to enable improved access in this group of patients.

Our finding that most of the patients with severe functional dependence (mRS 4-5) are assessed, referred and access rehabilitation is likely to be influenced by system drivers in addition to patient need. Prediction of final discharge disposition and pressures to discharge patients from acute hospital beds have a strong influence over assessment and recommendations regarding rehabilitation following stroke.^{26, 32} In Queensland, the major options for discharge which provide assistance with personal cares are residential aged care

facilities and “Transition Care” which is an aged care service in Australia providing low intensity rehabilitation in a mixture of home (supported discharge) and aged care facility settings.³³ Transition Care packages have limited availability consistent with the small proportion (6%) of more severely impaired patients in our cohort initially discharged to this service. The average length of hospital stay prior to a new admission to residential aged care in Australia is 28 days³⁴ which leads to high pressures to find alternate non acute destinations. These pressures within the acute care system may promote use of inpatient rehabilitation and may explain our subsequent comparatively high levels of access in the most functionally impaired patients who may appear to have greatest need. However, by over-riding rehabilitation selection processes the same pressures may disadvantage less functionally dependent patients who are able to be discharged home, but still have significant rehabilitation needs.

Clinical Messages

- Early functional impairment is the dominant patient factor influencing selection for rehabilitation after stroke.
- Gaps were identified in access to rehabilitation in people with mild to moderate impairment.

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Declaration of conflicting interests

No authors report potential conflicting interests.

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For Peer Review

Table 1. Patient factors and rehabilitation selection processes

Characteristic	All		Assessed for rehabilitation needs		Referred to Rehabilitation service		Received any Rehabilitation	
	n (%)		n (%)	P*	n (%)	P*	n (%)	P*
	504 (100)		454 (90)		381 (76)		363 (72)	
Median age (IQR [#])	73 (62, 82)		67 (57, 80)	0.06	74 (62, 82)	0.10	74 (62, 82)	0.06
Female	204 (41)		181 (40)	0.4	153 (40)	0.80	147 (41)	0.99
Previous stroke	71 (14)		63 (14)	0.68	56 (15)	0.49	49 (14)	0.54
Comorbidities								
Dementia	15 (3)		12 (3)	0.19	10 (3)	0.41	8(5.0)	0.1
End stage medical conditions [†]	76 (15)		70 (15)	0.5	53 (14)	0.2	45 (12)	<0.01
Pre-morbid dependence [§]	67 (13)		62 (13)	0.47 [‡]	58 (15)	0.03 [‡]	53 (15)	0.17 [‡]
Living arrangements:				0.16		0.16		0.05
Home alone	111 (22)		103 (23)		87 (23)		83 (23)	
Home with others	373 (74)		335 (74)		282 (74)		270 (74)	
Residential care	19 (4)		15 (3)		11 (3)		9 (3)	
Type of stroke [¶]				0.94		0.6		0.01
Ischaemic	434 (86)		391 (86)		325 (85)		303 (84)	
Haemorrhagic	68 (13)		61 (14)		54 (14)		59 (16)	
Modified Rankin Scale day3 [‡]				<0.01		<0.01		<0.01
0-1	88 (17)		59 (13)		28 (7)		27 (7)	
2-3	117(23)		110 (24)		89 (23)		78 (21)	
4-5	298 (59)		284 (63)		264 (69)		258 (59)	
Early impairments								
Motor	386 (77)		356 (78)	<0.01	310 (81)	<0.01	295 (81)	<0.01
Cognitive	169 (33)		161 (36)	<0.01	143 (38)	<0.01	137 (38)	<0.01
Speech/language	308 (61)		282 (62)	0.3	241 (63)	0.2	230 (64)	0.2

Sensory/perceptual	266 (53)	244(54)	0.2	213 (56)	0.01	201 (53)	0.06
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*vs not receiving selection process using Chi squared for categorical and Wilcoxon Mann-Whitney for continuous variables; #Inter Quartile Range; †premorbid co-morbidities substantially limiting ability to participate in rehabilitation, estimated prognosis less than 3-6 months, or altered stroke management decisions to palliative intent; §modified Rankin Scale score 3-5; ¶missing values for two cases, ‡missing value for one case, tests of significance unchanged when modified Rankin Scale treated as categorical variable.

For Peer Review

Table 2. Processes of care and rehabilitation selection processes

Characteristic	All	Assessed for rehabilitation needs		Referred to Rehabilitation service		Received any Rehabilitation	
		n (%)	P*	n (%)	P*	n (%)	P*
	504	454 (90)		381 (76)		363 (72)	
Stroke Unit Admission	441 (88)	403 (90)	0.01	338 (89)	0.15	318 (88)	0.9
Acute length of stay (median, IQR [#])	5 (3,9)	5 (3, 9)	<0.01	5 (3, 10)	<0.01	5 (3, 9)	<0.01
Allied health review:							
Physiotherapy	497 (99)	451 (99)	<0.01	379 (99)	<0.01	361 (99)	0.01
Occupational Therapy	459(97)	447 (99)	<0.01	376 (99)	<0.01	357 (98)	0.04
Speech Pathology	484 (96)	439 (97)	0.02	371 (97)	0.03	352 (97)	0.08
Social Work	289 (57)	271 (60)	<0.01	231 (61)	<0.01	217 (60)	0.07
Assessment for rehabilitation needs	454 (90)	-	-	376 (99)	<0.01	349 (96)	<0.01
Referral to rehabilitation service	381 (76)	-	-	-	-	345 (95)	<0.01

*vs not receiving selection process using Chi squared for categorical and Wilcoxon Mann-Whitney for continuous variables; [#]Inter Quartile Range

Table 3. Factors affecting rehabilitation selection processes – multivariable analysis†

Characteristic		Assessment for rehabilitation needs		Referred to Rehabilitation service		Received any Rehabilitation	
		Odds Ratio	95% CI#	Odds Ratio	95% CI#	Odds Ratio	95% CI#
Age (per decade)		1.0	1.0, 1.0	1.0	1.0, 1.0	1.0	1.0, 1.0
Stroke Unit admission		2.7	1.1, 6.6	1.0	0.4, 2.5	0.8	0.4, 1.8
Premorbid dependence*		0.6	0.2, 2.1	1.2	0.4, 3.3	0.8	0.3, 1.7
Dementia		0.3	0.1, 1.7	0.4	0.1, 2.1	0.2	0.1, 0.9
End stage medical conditions		1.2	0.4, 3.4	0.5	0.3, 1.2	0.4	0.2, 0.8
Stroke type (ischaemic)		1.9	0.7, 5.0	1.0	0.4, 2.4	0.4	0.1, 0.9
Modified Rankin Scale day 3	0-1	ref		ref		ref	
	2-3	7.3	2.7, 19.3	4.3	2.1, 9.0	3.0	1.5, 4.9
	4-5	10.9	4.9, 24.6	13.4	6.7, 27.1	12.5	6.5, 24.3
Assessment for rehabilitation needs		-	-	40.0	13.7, 116.2	6.5	2.9, 14.6

†Model includes all of the listed factors, adjusted for hospital as level, #95% Confidence Interval; *modified Rankin Scale 3-5;

Table 4. Rehabilitation selection processes by stroke severity*

Modified Rankin Scale day3	Assessed for rehabilitation needs N (%)	Rehabilitation needs identified N (%) [#]	Referred for rehabilitation N (%)	Received any rehabilitation [†] N (%)
0 (n=28)	17 (61)	3 (18)	2 (7)	6 (21)
1 (n=60)	42 (70)	28 (67)	26 (43)	17 (28)
2 (n=69)	63 (91)	49 (78)	47 (68)	38 (55)
3 (n=48)	47 (98)	42 (89)	42 (88)	35 (73)
4 (n=155)	149 (96)	138 (93)	137 (88)	121 (78)
5 (n=143)	135 (94)	124 (92)	127 (89)	128 (90)
Total (n=503) [#]	453 (90)	384 (85)	381 (76)	345 (69)

* Stroke Severity assessed by modified Rankin Scale on day 3 post stroke; [#]of those assessed for rehabilitation needs, [†]Receipt of rehabilitation defined as any allied health rehabilitation intervention within a rehabilitation service; [#]1 missing value.

Figure 1. Participant recruitment and rehabilitation selection processes flowchart

Supplementary Table 1. Characteristics of the sites

	Service type and location	Stroke admissions / year	Interventional neuro-radiology / Neurosurgery	Rehabilitation unit onsite	Notes
1	Comprehensive metropolitan	500	Yes	yes	
2	Comprehensive metropolitan	450	Yes	No	Geriatric Evaluation and Management unit on site
3	Small metropolitan with some tertiary services	150	No	Yes	
4	Small outer metropolitan	160	No	No	
5	Regional hub	550	No	No	
6	Regional hub	250	No	Yes	
7	Regional hub	300	No	Yes	Acute Stroke unit embedded within Rehabilitation unit
withdrawn	Small outer metropolitan	100	No	Yes	Withdrawn

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Supplementary Table 2. Characteristics of the 504 patients

Characteristic		N (%) (n=504)
Female		203 (40)
Age	Median (IQR [†])	72.7 (62, 82)
	< 65	160 (32)
	65-74	126 (25)
	75-84	146 (29)
	85+	71 (14)
Previous stroke		71 (14)
Premorbid dependency* (mRS 3-5)		66 (13)
Living arrangements	Home alone	111 (22)
	Home with others	373 (74)
	Supported accommodation	19 (4)
Type of stroke	Ischaemic	434 (86)
	Haemorrhagic	68 (13)

Modified Rankin Scale day 3 [#]	0	28 (6)
	1	60 (12)
	2	69 (14)
	3	48 (10)
	4	155 (31)
	5	143 (28)
Length of stay (days)	Median (IQR [‡])	5 (3, 9)
Discharge destination	Home	200 (40)
	Rehabilitation service	266 (52)
	Other admitted service	19 (4)
	Residential care facility	18 (4)
	Died	1 (0.2)

[‡]IQR – Inter Quartile Range; ^{*}modified Rankin Scale 3-5; [#]one case with missing data

Supplementary Table 3. Initial Rehabilitation Site by modified Rankin Scale score day 3 post stroke

Initial Rehabilitation site	modified Rankin Scale						
	All	0	1	2	3	4	5
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Inpatient	203 (40)	0 (0)	0 (0)	8 (12)	13 (27)	82 (53)	100 (70)
Community	115 (23)	6 (21)	16 (27)	28 (41)	18 (38)	31 (20)	16 (11)
Transition Care [†]	28 (6)	0 (0)	0 (0)	1 (2)	7 (15)	11 (7)	9 (6)
Other	17 (3)	0 (0)	5 (8)	3 (4)	0 (0)	4 (3)	5 (4)
No rehabilitation	141* (28)	22 (79)	39 (65)	29 (42)	10 (21)	27 (17)	13 (9)
Total	504*	28	60	69	48	155	143

[†]Transition Care is an aged care service in Australia providing low intensity rehabilitation in a mixture of home (supported discharge) and aged care facility setting²¹; *1 case with missing modified Rankin Scale data.

Supplementary Figure 1. Rehabilitation selection processes by hospital*

*expressed as percentage of total patients at each site