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The Excess Costs of Hospitalization for Acute Stroke in People With Communication Impairment: A Stroke123 Data Linkage Substudy

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The excess costs of hospitalization for acute stroke in people with communication impairment: a Stroke123 data linkage sub-study

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Abstract

Objective: There is limited published research on the excess costs of aphasia or dysarthria after stroke. We describe the costs of hospital care for acute stroke for patients with aphasia or dysarthria. **Design:** Observational study from the Stroke123 project. **Setting:** Data from patients admitted with stroke (2009-2013) from 22 hospitals in Queensland participating in the Australian Stroke Clinical Registry (AuSCR) were linked to administrative datasets. **Participants:** Communication impairments were identified using International Classification of Diseases 10th Revision Australian Modification codes. Overall, 1043/4195 (25%) patients were identified with aphasia (49% female; 78 median age; 83% ischaemic stroke), and 1005 (24%) with dysarthria (42% female; 76 median age; 85% ischaemic stroke). **Interventions:** N/A **Main Outcome Measures:** Linked patient-level, hospital clinical costing related to the stroke, were adjusted to 2013/2014 Australian dollars (AU$, US$ conversion x 0.691) using recommended national price indices and multivariable regression analysis with clustering by hospital performed. **Results:** Compared to patients without aphasia, the median hospital costs/patient were greater for those with aphasia for medical (aphasia AU$2273 vs. AU$1727, p<0.001), nursing (aphasia AU$3829 vs. AU$2748, p<0.001) and allied health services (aphasia AU$1138 vs. AU$720, p<0.001). Similarly, costs were greater for patients with dysarthria compared to those without dysarthria. Adjusted median total costs were AU$2882 greater for patients with aphasia compared to patients without aphasia (95%CI AU$1880 to AU$3884), and AU$843 greater for patients with dysarthria compared to those without dysarthria (95%CI AU$-301 to AU$1987). **Conclusion:** People with communication

impairment after stroke incur greater hospital costs, in particular for medical, allied health and nursing resources.

Keywords: stroke, aphasia, dysarthria, data linkage, cost analysis

Abbreviations

AuSCR- Australian Stroke Clinical Registry

IRSAD- Index of Relative Socioeconomic Advantage and Disadvantage

ICD-10-AM- The International Classification of Diseases 10th Revision Australian Modification

Communication impairment from aphasia or dysarthria occurs in up to 64% of survivors of stroke [1] and is associated with poor psychological, vocational and relational wellbeing [2-7]. Research into aphasia or difficulties expressing or understanding language, has been established as a priority by people living with stroke due to its effect on quality of life and current limited efficacy for behavioural treatment superiority [8]. Dysarthria affects speech intelligibility, not language and is a result of impaired motor function. It has a greater acute-phase prevalence than aphasia [1] however, limited published efficacy research in stroke [9].

Understanding the hospital costs associated with healthcare provision to survivors of stroke with communication impairments provides important information for decision making about resource allocation in stroke recovery and rehabilitation services. The costs of aphasia have been investigated in retrospective observational studies using linked data in the United States of America [6, 10, 11]. Costs were reported to be greater for those with aphasia during their inpatient stay [10] and across the first year post-stroke [6, 11] compared to those without aphasia. Race-ethnicity has been documented to influence medical costs for people with aphasia [12, 13]. Assessments of cost-effectiveness in aphasia treatment studies exist [14-17] however they do not provide data on routine practice or use population-level data. A significant gap exists concerning dysarthria, with no research pertaining to costs identified. Data in the Australian healthcare setting for people with aphasia and dysarthria have not been published using real-world population-level data.

Aim

The aim of this study was to describe the costs of hospital care for patients in the Australian healthcare setting after stroke with aphasia or dysarthria compared to patients without these communication impairments.

Methods

As part of the Stroke123 study, this observational study includes data on patients admitted with stroke or transient ischaemic attack (TIA) from hospitals participating in the Australian Stroke Clinical Registry (AuSCR). Data were linked to administrative datasets (emergency presentation, hospital admissions and death registrations). While the Stroke 123 study included patients from four states of Australia (Victoria, New South Wales, Queensland, and Western Australia), clinical costing data corresponding to the admissions in the AuSCR were obtained only for the cohort in Queensland. Details of the methods for the AuSCR and the Stroke123 study have been reported in previous publications [18, 19].

Briefly, the AuSCR is a standardized data collection program used to monitor the quality of acute care provided to patients admitted with stroke or TIA. A standardized minimum dataset is captured on consecutive patients including demographic and clinical characteristics, evidence-based therapies provided in hospital and patient outcomes. Data on the fact and cause of death for each patient were obtained from annual linkages between the AuSCR and the National Death Index.

For the Stroke123 study, data collected for the AuSCR between 2009–2013 were linked to hospital administrative datasets that have information on all presentations to public emergency departments and inpatient separations (discharges, transfers, deaths) from public, private, psychiatric, and repatriation hospitals. Data on emergency department presentations and hospital admissions occurring in the five years prior to the first stroke or TIA registered in the AuSCR were requested for each patient. The International Classification of Diseases 10th Revision Australian Modification (ICD-10-AM) codes associated with all emergency department presentations and hospital admissions related to the first stroke or TIA event recorded in the AuSCR and the five-years prior to the event were used to identify comorbidities and communication impairments.

In this study, only patients with a diagnosis of stroke (ischaemic stroke, intracerebral haemorrhage and underdetermined stroke) were included. Patients with aphasia (R470) or dysarthria (R471) related to their stroke were identified using ICD-10 codes associated with the emergency department presentations and hospital admissions related to the stroke event only. For the purposes of this paper, communication impairment refers to aphasia and dysarthria. We acknowledge the presence of other stroke related communication impairments such as apraxia of speech are not addressed in this study.

Clinical costing data

Clinical costing is the process of systematically determining the costs of the resources provided to patients by the healthcare provider. In Australia, clinical costing related to hospital admissions is conducted annually at public hospitals as part of the National Hospital Cost Data Collection [20] according to Australian Hospital Patient Costing Standards [21]. These data are subsequently used to determine activity-based funding (the amount that hospitals are reimbursed for each patient they treated based on the diagnosis-related group).

Briefly, care that is provided to patients that is documented in medical records and entered into the patient administration system is classified by health information managers and clinical coders into ICD-10-AM diagnosis codes and procedure codes. Hospital costing teams calculate costs of direct patient care and indirect costs (such as health service overheads) at an individual level for each admission. Costs calculated as part of this process include medical, nursing, non-clinical salaries, pathology, imaging, allied health, pharmacy, critical care, operating room, emergency department, ward supplies, special procedure suites, prostheses, oncosts, hotel, depreciation, and costs incurred in the emergency department.

The clinical costing records most relevant to the AuSCR record were identified using dates of admission and discharge and additional clinical records were removed.

All costs obtained for the current study were inflated to a 2013/2014 financial year equivalent using the Total Health Price Index [22]. The purchasing power parity conversion ratio from AU$ to US$ in 2013 was 0.6911 [23].

Statistics

Descriptive statistics appropriate to the distribution of the data were used and differences in patient characteristics between patient groups were assessed using $\chi 2$ tests for categorical variables and Kruskal-Wallis tests for continuous variables.

Due to the skewed distribution of the data, the additional costs associated with communication impairments were assessed using median regression analysis, with clustering by hospital. Aphasia and dysarthria were analysed separately. Variables associated with communication impairment, which were also associated with costs and changed the association by more than 10% were included in the multivariable models. Variables with a p-value <0.1 in univariable analysis were considered. Categorical variables were retained where one category of the variable had a $p<0.05$.

Age, sex, clinical diagnosis, Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD) quintiles for socioeconomic position, Aboriginal and/or Torres Strait Islander status, and place of birth (Australia or other), history of prior stroke and the ability to walk on admission to hospital as a marker of stroke severity were considered for inclusion in models [24]. Since this study included in-hospital strokes and transfers from another hospital, these variables were also considered in the multivariable models.

Data were analysed using STATA/SE 15.0 [25].

Ethics and data access

Ethics approval for the Stroke123 project in Queensland was obtained from ethics committees at Monash University (CF13/1303 – 2013000641), and Metro South Health (HREC/13/QPAH/31). Additional approvals to access and link these data were obtained from

the AuSCR Research Task Group and Department of Health Queensland. Patient-level data from this study cannot be shared. Qualified investigators may access the data after approval from ethics committees and data custodians.

Results

Patient characteristics

In this cohort of 4195 patients admitted with stroke, there were 1110 patients with aphasia (26.5%), 1005 with dysarthria (24.0%) and 249 (5.9%) with both aphasia and dysarthria. There were 1735 patients with either aphasia or dysarthria (41%). The majority of these were recorded and coded during the admission for the stroke; 1043 patients with aphasia (94.0%) and 941 patients with dysarthria (93.6%). A small proportion of patients had pre-existing aphasia (n=94, 2.24%).

Comparison of patients with and without aphasia

Patients with aphasia compared to those without aphasia, were older (median age 78 years vs 74 years, $p<0.001$), less likely to be transferred from another hospital (11% vs. 19%, $p<0.001$) or able to walk on admission (30% vs. 37%, $p<0.001$) (Table 1). Patients with aphasia were more likely to be treated in a stroke unit (81% vs. 73%, $p<0.001$) and be provided thrombolysis (14% vs. 6%, $p<0.001$). People with aphasia had a longer median length of stay by 2 days in hospital (8 vs 6 days, $p<0.001$), were less likely to be discharged home (32% vs. 46%, $p<0.001$) and were more likely to be discharged to aged care (9% vs. 7%, $p=0.012$) and rehabilitation (32% vs. 23%, $p<0.001$). Patients with aphasia were less likely to have died at seven days after admission (5% vs. 8%, $p=0.006$), but more likely at 180 days (24% vs. 20%, $p=0.001$) than those without aphasia.

Comparison of patients with and without dysarthria

Patients with dysarthria were more likely to be male (58% vs. 52%, p=0.001), be treated in a stroke unit (84% vs. 72%, p<0.001) and provided thrombolysis (13% vs. 7%, p<0.001) (Table 1). Patients with dysarthria were less likely to be transferred from another hospital (7% vs. 20%, p<0.001), be able to walk on admission (32% vs. 37%, p=0.018) or die in hospital (6% vs. 13%, p<0.001). Patients with dysarthria had a longer length of stay in hospital (7 vs. 6 days, p<0.001) and were more likely to be discharged with a care plan (47% vs. 38%, p=0.002) or to rehabilitation (32% vs. 23%, p<0.001) but less likely to be discharged home (32% vs. 46%, p<0.001). They were less likely to die at all time points after seven days post admission (p<0.001).

Costs

Aphasia

There were several differences in costs between patients with aphasia and those without (Table 2). In total, overall costs for patients with aphasia for their acute admission were AU$2846 higher than those without aphasia ($11,863 vs. $9017, p<0.05). Median per patient hospital costs were greater for medical ($2273 vs. $1727, p<0.05), nursing ($3829 vs. $2748, p<0.05), non-clinical salaries ($765 vs. $601, p<0.05), pathology ($334 vs. $267, p<0.05), ward supplies ($472 vs. $354, p<0.05), allied health services ($1138 vs. $720, p<0.05) and pharmacy services ($278 vs. $208, p<0.05).

Total costs per day differed and were frequently lower for those with aphasia compared to those without. Allied health costs per day were higher in those with aphasia than those without ($168 vs. $144, p<0.05).

Compared to those with aphasia AND dysarthria those with aphasia only had lower hospital admission costs (Supplementary Table I).

Dysarthria

There were several differences in costs between patients with dysarthria and those without (Table 3). In total, overall costs for patients with dysarthria were AU$1944 greater than those without ($11,285 vs. $9341, $p<0.05$). Compared to patients without dysarthria, patients with dysarthria had greater median per patient hospital costs for medical ($2147 vs. $1776, $p<0.05$), nursing ($3437 vs. $2823, $p<0.05$), non-clinical salaries ($676 vs. $629, $p<0.05$), pathology ($329 vs. $269, $p<0.05$), imaging ($752 vs. $658, $p<0.05$), ward supplies ($429 vs. $373, $p<0.05$), allied health services ($1081 vs. $728, $p<0.05$) and pharmacy services ($259 vs. $217, $p<0.05$).

Costs per day were greater for patients with dysarthria for allied health costs ($184 vs. $139, $p<0.05$) but less for critical care costs ($336 vs. $669, $p<0.05$).

Compared to those with aphasia AND dysarthria those with dysarthria only had lower costs (Supplementary Table II).

Additional costs associated with communication impairment in multivariable analysis

No factors were found to confound the association between aphasia and total costs, and between aphasia and medical and nursing ward costs (Table 4). After adjustment for confounding factors, allied health costs were AU$292 greater than for patients without aphasia (95% confidence interval $45 to $539). After adjustment, dysarthria was not associated with an increased total cost but was associated with greater medical and nursing ward and allied health costs (Table 5).

Discussion

To our knowledge, this is the first detailed report of costs related to acute hospital admissions for stroke according to the presence of communication impairments (aphasia and dysarthria). The costs were estimated using a standardized method applied by a government agency

responsible for detailing the expenditure associated with individual hospital admissions. This appeared to be a typical stroke cohort, with prevalence of aphasia (26.5%) and dysarthria (24.0%) comparable to previous studies [1, 26]. There was evidence that amongst this cohort of patients with stroke, communication impairments were associated with increased costs relative to those without these impairments. Stroke is already a costly condition and requires interdisciplinary management. Among hospitals that treat a large proportion of cases with communication impairments the funding models need to be reviewed to ensure sufficient reimbursement. This is necessary to guarantee that hospitals can provide the interdisciplinary resources needed to treat and rehabilitate these patients.

The differences in characteristics observed between patients with aphasia or dysarthria and those without may reflect the nature and severity of the stroke event. In particular, aphasia is associated with stroke events involving the middle cerebral artery in the dominant hemisphere which are typically more severe than posterior circulation events [27], and are often associated with hemiparesis.[26] Patients presenting with diagnosed aphasia or dysarthria persisting beyond initial stroke onset symptoms are more likely to have experienced an ischemic stroke and received thrombolysis [28]. Some of the differences in costs between those with and without impairments may be partially attributable to a greater proportion of patients with speech impairment after stroke being provided thrombolysis and treatment in a stroke unit, since these are associated with greater costs.[29]

Impairments in speaking and walking have a significant impact on everyday activities and lead to a worse clinical outcome.[30] This is likely reflected in the increased length of stay for the acute hospital admission, as well as increased costs in allied health, medical and nursing services found in our analyses. Several studies have documented the increased length of stay for people with aphasia.[10, 26, 30, 31] In conjunction with stroke severity, increased length of stay may also reflect people with communication impairments waiting longer for discharge

destinations such as inpatient rehabilitation to become available, as they are significantly less likely to be discharged directly home following the acute event. The lower cost per day of people with aphasia, reflects their increased length of stay with higher costs dispersed over a greater number of days (data not shown). Indeed, we generally found that found that costs were significantly different between groups, but not when considering cost per day. Allied health costs per day, however, were higher, likely reflecting greater rehabilitation requirements which needs to be accounted for in reimbursement systems.

People with aphasia were more likely to be older than those without, consistent with previous findings [6, 10, 28]. Those that are older are more likely to have aphasia and place a greater monetary burden on the health care system [6]. Increased mortality for patients with aphasia has been reported [10, 32] reflected in this study at 6 months post stroke. Overall, these statistics reflect the vulnerable nature of this population. Survival rate for dysarthria was not different to those without at all time points.

Comparison with previous studies on the cost of aphasia are difficult due to considerable differences in methodology and healthcare settings. In the most comparable study the cost of admission for a person with aphasia was US$971.35 (AU$1252 in 2021) greater than those without [10]. However, the study was conducted in the US setting and had a mean length of stay of 6.2 days. The average length of stay in our Australian cohort (mean 13 days, data not shown) and differences in service delivery models explain the differences in costs observed between studies.

Our study has several strengths. Data were obtained for a large cohort of patients admitted to major hospitals treating stroke in one state of Australia. A clinical diagnosis recorded in the AuSCR was used to identify stroke. There is a dearth of economic literature on dysarthria and this study provides a first-time insight into quantifying the cost.

The study has several limitations including the reliance on the assignment of ICD-10-AM codes for the presence/absence of aphasia or dysarthria rather than clinical diagnosis. Australian diagnostic coding guidelines require that a clinical condition must significantly affect patient management and be sufficiently documented in the medical record to be included in diagnostic codes [33], however, there is a possibility that some patients with communication impairment may have been missed or misclassified. Since data collection in 2013 there have been several changes to the provision of acute stroke care, including the implementation of endovascular clot retrieval. Although almost 10 years old, these data remain the most current for an Australian cohort with communication impairment after stroke. We acknowledge that we lacked other information about the range of impairments as a consequence of stroke within the cohort, and our measure of stroke severity, ability to walk on admission, is a global measure that may not discriminate aspects of stroke severity more fully, such as the National Institutes of Health Stroke Scale score. Nonetheless this variable has been used in prior research and has been found to be a good prognostic measure of stroke outcome.[24] People with communication problems do tend to have a greater increased stroke severity from a range of impairments.[26] It would also have been pertinent to investigate how aphasia and dysarthria affected the provision of speech and language therapy specifically, but further cost breakdowns other than those presented were unavailable. It is not possible to determine if the speech impairment had resolved by the time of discharge since if aphasia/dysarthria are noted anywhere in the clinical notes, it should be coded. Therefore, transient communication impairments may have been captured and the data cannot be used to ascertain evolution of communication impairment. Our data were also only available from one state of Australia and may not be representative of other locations.

Although it was beyond the scope of this study, the financial burden of inpatient rehabilitation stays and residential and aged care related costs for people with aphasia or

dysarthria would likely be considerable and contribute to health system expenditure. It has also been documented that survivors of stroke with aphasia are less likely to return to work [34], in particular younger survivors [35] and are isolated in the community [36] with higher rates of anxiety and depression [37, 38] than stroke survivors without aphasia. The productive losses and associated costs of increased unemployment or not being able to return to work impact the broader society and individuals.

Conclusion

Communication impairments were associated with increased costs of hospital admissions after acute stroke mainly attributable to increased use of interdisciplinary services compared to patients without these impairments. It is imperative that the increased demand on resources, particularly related to allied health and nursing, be considered in budgeting and staffing decisions. Further research is required to optimise speech and language therapy after stroke and investigate interventions which maximise both the efficiency of care and outcomes across the continuum of care.

Data Availability

Patient-level data from this study cannot be shared. Qualified investigators may access the data after approval from ethics committees and data custodians.

References

1. Mitchell C, Gittins M, Tyson S, Vail A, Conroy P, Paley L, et al. Prevalence of aphasia and dysarthria among inpatient stroke survivors: Describing the population, therapy provision and outcomes on discharge. *Aphasiology*. 2020:1-11
2. Lam JM, Wodchis WP. The relationship of 60 disease diagnoses and 15 conditions to preference-based health-related quality of life in ontario hospital-based long-term care residents. *Med Care*. 2010;48:380-387
3. Hilari K, Byng S. Health-related quality of life in people with severe aphasia. *International journal of language & communication disorders*. 2009;44:193-205
4. Bartlett G, Blais R, Tamblyn R, Clermont RJ, MacGibbon B. Impact of patient communication problems on the risk of preventable adverse events in acute care settings. *Cmaj*. 2008;178:1555-1562
5. Davidson B, Howe T, Worrall L, Hickson L, Togher L. Social participation for older people with aphasia: The impact of communication disability on friendships. *Top Stroke Rehabil*. 2008;15:325-340
6. Ellis C, Simpson AN, Bonilha H, Mauldin PD, Simpson KN. The one-year attributable cost of poststroke aphasia. *Stroke*. 2012;43:1429-1431
7. Brady MC, Clark AM, Dickson S, Paton G, Barbour RS. The impact of stroke-related dysarthria on social participation and implications for rehabilitation. *Disabil Rehabil*. 2011;33:178-186
8. Pollock A, St George B, Fenton M, Firkins L. Top ten research priorities relating to life after stroke. *Lancet Neurology*. 2012;11:209
9. Mitchell C, Bowen A, Tyson S, Butterfint Z, Conroy P. Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury. *Cochrane Database of Systematic Reviews*. 2017
10. Wu C, Qin Y, Lin Z, Yi X, Wei X, Ruan Y, et al. Prevalence and impact of aphasia among patients admitted with acute ischemic stroke. *Journal of Stroke and Cerebrovascular Diseases*. 2020;29
11. Jacobs M, Ellis C. Aphasianomics: Estimating the economic burden of poststroke aphasia in the united states. *Aphasiology*. 2021:1-14
12. Hardy RY, Lindrooth RC, Peach RK, Ellis C. Urban-rural differences in service utilization and costs of care for racial-ethnic groups hospitalized with poststroke aphasia. *Archives of Physical Medicine and Rehabilitation*. 2019;100:254-260
13. Ellis C, Hardy RY, Lindrooth RC. Greater healthcare utilization and costs among black persons compared to white persons with aphasia in the north carolina stroke belt. *Journal of the Neurological Sciences*. 2017;376:76-83
14. Wenke R, Lawrie M, Hobson T, Comben W, Romano M, Ward E, et al. Feasibility and cost analysis of implementing high intensity aphasia clinics within a sub-acute setting. *International journal of speech-language pathology*. 2014;16:250-259
15. Palmer R, Cooper C, Enderby P, Brady M, Julious S, Bowen A, et al. Clinical and cost effectiveness of computer treatment for aphasia post stroke (big cactus): Study protocol for a randomised controlled trial. *Trials*. 2015;16:18-18
16. Marshall J, Booth T, Devane N, Galliers J, Greenwood H, Hilari K, et al. Evaluating the benefits of aphasia intervention delivered in virtual reality: Results of a quasi-randomised study. *Plos One*. 2016;11:e0160381-e0160381
17. Jacobs M, Briley PM, Wright HH, Ellis C. Marginal assessment of the cost and benefits of aphasia treatment: Evidence from community-based telerehabilitation treatment for aphasia. *Journal of Telemedicine and Telecare*. 2021:1357633X20982773

18. Cadilhac DA, Lannin NA, Anderson CS, Levi CR, Faux S, Price C, et al. Protocol and pilot data for establishing the australian stroke clinical registry. *Int J Stroke*. 2010;5:217-226
19. Kilkenny MF, Kim J, Andrew NE, Sundararajan V, Thrift AG, Katzenellenbogen JM, et al. Maximising data value and avoiding data waste: A validation study in stroke research. *Med J Aust*. 2019;210:27-31
20. Independent Hospital Pricing Authority. National hospital cost data collection, https://www.Ihpa.Gov.Au/what-we-do/nhcdc (accessed 18 january 2021).
21. Independent Hospital Pricing Authority. Australian hospital patient costing standards v4.0, https://www.Ihpa.Gov.Au/ahpcs (accessed 18 january 2021).
22. Australian Institute of Health and Welfare. Health expenditure australia 2017-18, https://www.Aihw.Gov.Au/reports/health-welfare-expenditure/health-expenditure-australia-2017-18/contents/summary (accessed 7 august 2020).
23. Organisation for Economic Co-operation and Development. Purchasing power parities 2021
24. Cadilhac DA, Kilkenny MF, Levi CR, Lannin NA, Thrift AG, Kim J, et al. Risk-adjusted hospital mortality rates for stroke: Evidence from the australian stroke clinical registry (auscr). *Med J Aust*. 2017;206:345-350
25. StataCorp. Stata statistical software: Release 15. 2017
26. Flowers HL, Silver FL, Fang J, Rochon E, Martino R. The incidence, co-occurrence, and predictors of dysphagia, dysarthria, and aphasia after first-ever acute ischemic stroke. *J Commun Disord*. 2013;46:238-248
27. De Marchis GM, Kohler A, Renz N, Arnold M, Mono ML, Jung S, et al. Posterior versus anterior circulation strokes: Comparison of clinical, radiological and outcome characteristics. *J Neurol Neurosurg Psychiatry*. 2011;82:33-37
28. Engelter ST, Gostynski M, Papa S, Frei M, Born C, Ajdacic-Gross V, et al. Epidemiology of aphasia attributable to first ischemic stroke: Incidence, severity, fluency, etiology, and thrombolysis. *Stroke*. 2006;37:1379-1384
29. Kim J, Grimley R, Kilkenny MF, Cadigan G, Johnston T, Andrew NE, et al. Costs of acute hospitalisation for stroke and transient ischaemic attack in australia. *Health Information Management Journal*. 2022;0:18333583221090277
30. Wee JYM, Hopman WM. Stroke impairment predictors of discharge function, length of stay, and discharge destination in stroke rehabilitation. *American Journal of Physical Medicine & Rehabilitation*. 2005;84
31. Guyomard V, Fulcher RA, Redmayne O, Metcalf AK, Potter JF, Myint PK. Effect of dysphasia and dysphagia on inpatient mortality and hospital length of stay: A database study. *Journal of the American Geriatrics Society*. 2009;57:2101-2106
32. Laska AC, Hellblom A, Murray V, Kahan T, Von Arbin M. Aphasia in acute stroke and relation to outcome. *J Intern Med*. 2001;249:413-422
33. Australian Consortium for Classification Development. International classification of diseases-10-australian modification. 2019
34. Dalemans RJP, De Witte LP, Wade DT, Van den Heuvel WJA. A description of social participation in working-age persons with aphasia: A review of the literature. *Aphasiology*. 2008;22:1071-1091
35. Graham JR, Pereira S, Teasell R. Aphasia and return to work in younger stroke survivors. *Aphasiology*. 2011;25:952-960
36. Hilari K. The impact of stroke: Are people with aphasia different to those without? . *Disability & Rehabilitation*. 2011;33:211-218

Supplementary Table I. Comparison of aphasia only to aphasia and dysarthria

	Overall cost				Cost per day			
	Aphasia only		Aphasia and dysarthria		Aphasia only		Aphasia and dysarthria	
	N	Median $AU (IQR)	N	Median $AU (IQR)	N	Median $AU (IQR)	N	Median $AU (IQR)
Ward Medical	603	2193 (1200 ,3956)	210	2533 (1656 ,4071)	602	318 (191 ,482)	210	338 (191 ,521)
Ward Nursing	604	3812 (1884 ,6629)	210	3980 (2526 ,6767)	603	496 (343 ,888)	210	537 (381 ,841)
Non clinical *	603	751 (386 ,1279)	210	793 (450 ,1297)	602	105 (68 ,180)	210	106 (71 ,187)
Pathology	550	330 (128 ,709)	195	343 (164 ,752)	549	49 (19 ,89)	195	46 (24 ,84)
Imaging	555	702 (321 ,1386)	197	810 (415 ,1331)	554	95 (36 ,197)	197	89 (45 ,185)
Allied Health	602	1005 (368 ,2297)	210	1518 (646 ,2941)	601	153 (63 ,294)	210	202 (100 ,384)
Pharmacy	604	273 (112 ,527)	210	283 (153 ,512)	603	32 (17 ,65)	210	33 (20 ,69)
Critical Care	69	3091 (810 ,6863)	35	2657 (452 ,8069)	69	487 (122 ,1196)	35	295 (72 ,734)
Operating Rooms	145	3 (2 ,184)	52	2 (2 ,2)	145	1 (0 ,13)	52	0 (0 ,1)
Ward Supplies	604	467 (256 ,797)	210	532 (303 ,1002)	603	63 (46 ,103)	210	72 (51 ,110)
Special Procedure Suites	6	1128 (101 ,3073)	3	108 (52 ,2504)	6	86 (9 ,210)	3	18 (9 ,313)
Prosthesis	560	2 (0 ,9)	205	3 (1 ,10)	559	0 (0 ,1)	205	0 (0 ,1)
On costs †	604	716 (393 ,1297)	210	831 (539 ,1433)	603	106 (65 ,170)	210	115 (79 ,180)
Hotel ‡	604	170 (88 ,341)	210	188 (107 ,396)	603	25 (14 ,43)	210	29 (18 ,49)
Depreciation	604	92 (38 ,197)	210	118 (57 ,193)	603	11 (5 ,32)	210	13 (7 ,30)
Total	604	11551 (6331 ,20300)	210	12885 (8862 ,20875)	603	1519 (1123 ,2798)	210	1654 (1257 ,2784)

Median and IQR (interquartile range) reported are amongst those incurring the cost.

$p<0.05$ for differences between groups in overall cost only: Ward Medical, Total

$p<0.05$ for differences between groups in overall cost and cost per day: Allied Health, Operating Rooms, Ward Supplies, Prosthesis, On costs, Hotel

* includes patient transport

† Staff on costs (additional allowances such as superannuation and annual leave)

‡ Includes expenses related to cleaning, laundry, food and general hotel services

AU$: Australian dollars, to convert to US$ multiply by 0.6911

Supplementary Table II. Comparison of dysarthria only to aphasia and dysarthria

	Overall cost				Cost per day			
	Dysarthria only		Aphasia and dysarthria		Dysarthria only		Aphasia and dysarthria	
	N	Median $AU (IQR)	N	Median $AU (IQR)	N	Median $AU (IQR)	N	Median $AU (IQR)
Ward Medical	543	1926 (1124 ,3226)	210	2533 (1656 ,4071)	543	331 (180 ,496)	210	338 (191 ,521)
Ward Nursing	544	3269 (1739 ,5262)	210	3980 (2526 ,6767)	544	504 (353 ,810)	210	537 (381 ,841)
Non clinical *	544	648 (366 ,1162)	210	793 (450 ,1297)	544	110 (70 ,185)	210	106 (71 ,187)
Pathology	490	327 (143 ,632)	195	343 (164 ,752)	490	54 (24 ,100)	195	46 (24 ,84)
Imaging	507	742 (314 ,1414)	197	810 (415 ,1331)	507	105 (46 ,227)	197	89 (45 ,185)
Allied Health	542	935 (388 ,2228)	210	1518 (646 ,2941)	542	174 (80 ,305)	210	202 (100 ,384)
Pharmacy	544	250 (102 ,495)	210	283 (153 ,512)	544	34 (17 ,70)	210	33 (20 ,69)
Critical Care	79	3057 (332 ,12217)	35	2657 (452 ,8069)	79	347 (37 ,1529)	35	295 (72 ,734)
Operating Rooms	133	2 (2 ,17)	52	2 (2 ,2)	133	1 (0 ,2)	52	0 (0 ,1)
Ward Supplies	544	395 (217 ,704)	210	532 (303 ,1002)	544	63 (46 ,99)	210	72 (51 ,110)
Special Procedure Suites	12	485 (108 ,1444)	3	108 (52 ,2504)	12	46 (20 ,109)	3	18 (9 ,313)
Prosthesis	520	2 (1 ,8)	205	3 (1 ,10)	520	0 (0 ,1)	205	0 (0 ,1)
On costs †	544	657 (361 ,1151)	210	831 (539 ,1433)	544	111 (71 ,176)	210	115 (79 ,180)
Hotel ‡	544	151 (77 ,301)	210	188 (107 ,396)	544	25 (17 ,42)	210	29 (18 ,49)
Depreciation	544	98 (40 ,205)	210	118 (57 ,193)	544	14 (6 ,34)	210	13 (7 ,30)
Total	544	10618 (6150 ,17752)	210	12885 (8862 ,20875)	544	1584 (1201 ,2787)	210	1654 (1257 ,2784)

Median and IQR (interquartile range) reported are amongst those incurring the cost.

p<0.05 for differences between groups in overall cost only: Ward Medical, Ward Nursing, Non-clinical, Pharmacy, Ward Supplies, Prosthesis, On costs, Hotel, Depreciation, Total

p<0.05 for differences between groups in overall cost only: Ward Medical, Ward Nursing, Non-clinical, Pharmacy, Prosthesis, On costs, Depreciation, Total

p<0.05 for differences between groups in overall cost and cost per day: Allied Health, Ward Supplies, Hotel

* includes patient transport

† Staff on costs (additional allowances such as superannuation and annual leave)

‡ Includes expenses related to cleaning, laundry, food and general hotel services

AU$: Australian dollars, to convert to US$ multiply by 0.6911

37. Kauhanen M, Korpelainen JT, Hiltunen P, Brusin E, Mononen H, Määttä R, et al. Poststroke depression correlates with cognitive impairment and neurological deficits. *Stroke*. 1999;30:1875-1880
38. Morris R, Eccles A, Ryan B, Kneebone II. Prevalence of anxiety in people with aphasia after stroke. *Aphasiology*. 2017;31:1410-1415

Tables

Table 1. Characteristics of patients with and without aphasia, dysarthria

	Aphasia			**Dysarthria**		
	No	**Yes**	**p-value**	**No**	**Yes**	**p-value**
	N=3152	**N=1043**		**N=3254**	**N=941**	
	n (%)	**n (%)**		**n (%)**	**n (%)**	
Age (years)			<0.001			0.089
<65	913 (29)	229 (22)		916 (28)	226 (24)	
65-74	695 (22)	231 (22)		708 (22)	218 (23)	
75-84	913 (29)	302 (29)		939 (29)	276 (29)	
85+	623 (20)	278 (27)		685 (21)	216 (23)	

Median age in years (IQR)*	74 (63, 83)	78 (66, 86)	<0.001	75 (63, 84)	76 (65, 84)	0.071
Male	1713 (54)	533 (51)	0.070	1699 (52)	547 (58)	0.001
Born in Australia	2281 (72)	715 (69)	0.018	2334 (72)	662 (70)	0.410
Transferred from another hospital	591 (19)	117 (11)	<0.001	641 (20)	67 (7)	<0.001
In-hospital stroke	207 (7)	59 (6)	0.274	220 (7)	46 (5)	0.034
Ability to walk on admission	1045 (37)	289 (30)	<0.001	1056 (37)	278 (32)	0.018
Prior history of stroke	616 (21)	221 (22)	0.323	646 (21)	191 (21)	0.956
Clinical diagnosis			<0.001			<0.001
Intracerebral haemorrhage	569 (18)	119 (11)		601 (18)	87 (9)	
Ischemic stroke	2319 (74)	862 (83)		2385 (73)	796 (85)	
Undetermined stroke	264 (8)	62 (6)		268 (8)	58 (6)	
Treated in a stroke unit	2298 (73)	844 (81)	<0.001	2356 (72)	786 (84)	<0.001
Provided thrombolysis (if an ischaemic stroke)	143 (6)	117 (14)	<0.001	157 (7)	103 (13)	<0.001
Median length of stay in days (IQR)	6 (3, 11)	8 (4, 15)	<0.001	6 (3, 12)	7 (4, 14)	<0.001

Discharged on an antihypertensive medication	1755 (65)	636 (70)	0.010	1773 (64)	618 (72)	<0.001
Discharged with a care plan	556 (39)	154 (41)	0.387	548 (38)	162 (47)	0.002
Died in hospital	348 (12)	89 (9)	0.017	383 (13)	54 (6)	<0.001
Discharge destination						
Aged care	181 (7)	84 (9)	0.012	196 (7)	69 (8)	0.345
Rehabilitation	628 (23)	288 (32)	<0.001	639 (23)	277 (32)	<0.001
Home	1247 (46)	288 (32)	<0.001	1258 (46)	277 (32)	<0.001
Timing of death after admission						
Died at 7 days	243 (8)	54 (5)	0.006	274 (8)	23 (2)	<0.001
Died at 30 days	446 (14)	147 (14)	0.964	515 (16)	78 (8)	<0.001
Died at 90 days	559 (18)	201 (19)	0.264	644 (20)	116 (12)	<0.001
Died at 180 days	621 (20)	255 (24)	0.001	731 (22)	145 (15)	<0.001

*IQR: interquartile range

Table 2. Overall costs and costs per day stratified by aphasia classification

	Overall cost				Cost per day			
	No Aphasia		Aphasia		No Aphasia		Aphasia	
	N	Median AU$ (IQR)	N	Median AU$ (IQR)	N	Median AU$ (IQR)	N	Median AU$ (IQR)
Ward Medical	2150	1727 (910 ,3034)	813	2273 (1278 ,3985)	2144	326 (178 ,506)	812	320 (191 ,493)
Ward Nursing	2158	2748 (1376 ,4998)	814	3829 (2073 ,6629)	2152	489 (334 ,826)	813	505 (357 ,881)
Non-clinical *	2158	601 (321 ,1072)	813	765 (405 ,1279)	2152	111 (69 ,188)	812	105 (68 ,182)
Pathology	1945	267 (113 ,608)	745	334 (141 ,716)	1940	52 (22 ,105)	744	48 (22 ,88)
Imaging	1910	676 (308 ,1280)	752	730 (353 ,1341)	1905	114 (50 ,231)	751	94 (38 ,190)
Allied Health	2138	720 (266 ,1740)	812	1138 (433 ,2466)	2133	144 (66 ,264)	811	168 (76 ,314)
Pharmacy	2157	208 (84 ,443)	814	278 (123 ,520)	2151	32 (16 ,71)	813	32 (18 ,66)
Critical Care	272	5139 (662 ,15906)	104	2849 (647 ,7377)	271	602 (126 ,2302)	104	421 (113 ,987)

Operating Rooms	538	2 (2 ,83)	197	2 (2 ,109)	538	1 (0 ,11)	197	1 (0 ,10)
Ward Supplies	2158	354 (186 ,637)	814	472 (276 ,832)	2152	65 (44 ,100)	813	66 (47 ,104)
Special Procedure Suites	40	402 (105 ,1316)	9	1107 (101 ,2504)	40	38 (12 ,136)	9	60 (9 ,210)
Prosthesis	1967	1 (0 ,6)	765	2 (1 ,9)	1962	0 (0 ,1)	764	0 (0 ,1)
On costs †	2158	561 (281 ,1012)	814	745 (428 ,1302)	2152	108 (65 ,169)	813	109 (68 ,174)
Hotel ‡	2158	129 (64 ,257)	814	177 (90 ,354)	2152	25 (15 ,43)	813	26 (15 ,45)
Depreciation	2158	84 (30 ,184)	814	102 (42 ,197)	2152	14 (5 ,36)	813	12 (5 ,31)
Exclude (ED Procedures)	42	0 (0 ,0)	10	0 (0 ,0)	42	0 (0 ,0)	10	0 (0 ,0)
Total	2158	9017 (5020 ,16152)	814	11863 (6865 ,20337)	2152	1620 (1148 ,2833)	813	1580 (1163 ,2789)

Median and IQR (interquartile range) reported are amongst those incurring the cost.
$p<0.05$ for differences between groups in overall cost only: Ward Medical, Ward Nursing, Non-clinical, Pharmacy, Ward Supplies, Prosthesis, On costs, Hotel, Depreciation, Total
$p<0.05$ for differences between groups in cost per day only: Imaging
$p<0.05$ for differences between groups in overall cost and cost per day: Pathology, Allied Health, Critical Care
* includes patient transport
† Staff on costs (additional allowances such as superannuation and annual leave)
‡ Includes expenses related to cleaning, laundry, food and general hotel services
AU$: Australian dollars, to convert to US$ multiply by 0.6911

Table 3. Overall costs and costs per day stratified by dysarthria classification

	Overall cost				Cost per day			
	No Dysarthria		Dysarthria		No Dysarthria		Dysarthria	
	N	Median AU$ (IQR)	N	Median AU$ (IQR)	N	Median AU$ (IQR)	N	Median AU$ (IQR)
Ward Medical	2210	1776 (936 ,3220)	753	2147 (1252 ,3440)	2203	321 (180 ,504)	753	333 (185 ,502)
Ward Nursing	2218	2823 (1395 ,5376)	754	3437 (2007 ,5775)	2211	488 (329 ,843)	754	509 (360 ,828)
Non-clinical *	2217	629 (324 ,1110)	754	676 (385 ,1186)	2210	110 (69 ,186)	754	109 (71 ,186)
Pathology	2005	269 (110 ,634)	685	329 (148 ,658)	1999	51 (20 ,103)	685	52 (24 ,96)
Imaging	1958	658 (308 ,1261)	704	752 (344 ,1374)	1952	110 (46 ,223)	704	100 (45 ,211)
Allied Health	2198	728 (268 ,1771)	752	1081 (447 ,2414)	2192	139 (62 ,265)	752	184 (88 ,329)
Pharmacy	2217	217 (85 ,454)	754	259 (114 ,500)	2210	32 (16 ,69)	754	33 (18 ,70)
Critical Care	262	4862 (810 ,15727)	114	2836 (390 ,11793)	261	669 (162 ,2143)	114	336 (56 ,1096)

Operating Rooms	550	3 (2 ,106)	185	2 (2 ,9)	550	1 (0 ,12)	185	1 (0 ,2)
Ward Supplies	2218	373 (192 ,670)	754	429 (238 ,759)	2211	65 (44 ,101)	754	66 (47 ,103)
Special Procedure Suites	34	548 (101 ,1370)	15	402 (108 ,1964)	34	43 (11 ,173)	15	40 (15 ,114)
Prosthesis	2007	1 (0 ,7)	725	2 (1 ,8)	2001	0 (0 ,1)	725	0 (0 ,1)
On costs †	2218	574 (286 ,1048)	754	704 (391 ,1203)	2211	107 (64 ,168)	754	112 (72 ,177)
Hotel ‡	2218	132 (64 ,269)	754	162 (86 ,331)	2211	25 (15 ,43)	754	27 (17 ,45)
Depreciation	2218	84 (30 ,182)	754	104 (43 ,203)	2211	13 (5 ,36)	754	14 (6 ,32)
Exclude (ED Procedures)	47	0 (0 ,0)	5	0 (0 ,0)	47	0 (0 ,0)	5	0 (0 ,0)
Total	2218	9341 (5028 ,16906)	754	11285 (6614 ,19000)	2211	1604 (1131 ,2833)	754	1612 (1218 ,2784)

Median and IQR (interquartile range) reported are amongst those incurring the cost.
$p<0.05$ for differences between groups in overall cost only: Ward Medical, Ward Nursing, Non-clinical, Pathology, Imaging, Pharmacy, Ward Supplies, Depreciation, Total
$p<0.05$ for differences between groups in overall cost and cost per day: Allied Health, Critical Care, Operating Rooms, Prosthesis, On costs, Hotel
* includes patient transport
† Staff on costs (additional allowances such as superannuation and annual leave)
‡ Includes expenses related to cleaning, laundry, food and general hotel services
AU$: Australian dollars, to convert to US$ multiply by 0.6911

Table 4. Additional costs associated with aphasia compared to people with stroke and no aphasia

	Total costs	Medical and nursing ward costs (AU$)	Allied health costs (AU$)
	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)
Aphasia	2882 (1880, 3884)	1613 (1139, 2086)	292 (45, 539)
Index of Relative Socioeconomic Advantage and Disadvantage			
Quintile 1 (most relative disadvantage)	-	-	Reference
Quintile 2	-	-	225 (2, 447)
Quintile 3	-	-	328 (104, 551)
Quintile 4	-	-	399 (160, 638)
Quintile 5 (least relative disadvantage)	-	-	416 (130, 701)
Ability to walk on admission	-	-	-374 (-567, -180)

AU$: Australian dollars, to convert to US$ multiply by 0.6911

Table 5. Additional cost associated with dysarthria compared to people with stroke and no dysarthria

	Total costs	**Medical and nursing ward costs (AU$)**	**Allied health costs (AU$)**
	Coefficient (95% CI)	**Coefficient (95% CI)**	**Coefficient (95% CI)**
Dysarthria	843 (-301, 1987)	738 (162, 1313)	286 (87, 486)
Index of Relative Socioeconomic Advantage and Disadvantage			
Quintile 1 (most relative disadvantage)	Reference	-	Reference
Quintile 2	1626 (531, 2721)	-	232 (21, 443)
Quintile 3	2790 (1528, 4052)	-	387 (173, 601)
Quintile 4	1796 (698, 2893)	-	416 (182, 650)
Quintile 5 (least relative disadvantage)	2237 (1038, 3435)	-	467 (196, 738)
Ability to walk on admission	-3728 (-4788, -2667)	-1437 (-2168, -707)	-395 (-595, -195)

AU$: Australian dollars, to convert to US$ multiply by 0.6911