

## Evaluation of adult stroke presentations at an Emergency Department in Queensland Australia



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### ARTICLE INFO

#### Keywords:

Stroke  
Emergency care  
Triage assessments

### ABSTRACT

**Background:** Stroke is a leading cause of mortality and morbidity which places high demands on emergency departments (EDs). Currently there is limited data on stroke presentations to Australian EDs and the time performance management of these presentations. Therefore, the aim of this study was to evaluate stroke presentations at an ED in Queensland, Australia in terms of demographics and time performance measures over a five year period.

**Methods:** Retrospective analysis of ED presentations by patients  $\geq 18$  years with a final diagnosis of stroke between 1 July 2010 and 30 June 2015.

**Results:** Over the five years there was a 51.4% increase in presentations diagnosed with stroke. The majority of these patients arrived by ambulance (71.0%) and were admitted (94.9%) with death in ED for 1.4% of presentations. From 2010 to 2015 for both haemorrhagic and ischaemic stroke there was a significant decrease in median LOS in ED (435 to 215 min,  $p < 0.05$  and 451 to 238 min,  $p < 0.001$  respectively) and in the proportion of patients in ED greater than four hours (82.4% to 44%,  $p < 0.05$  and 92.4% to 45.8%,  $p < 0.0001$  respectively).

**Conclusion:** Despite increased presentations of stroke, the ED improved in multiple time performance measures. Improving time-based targets in ED is particularly important for stroke presentations given the time critical nature of stroke management.

### 1. Introduction

Stroke is a leading cause of morbidity and mortality worldwide with the overall stroke burden increasing globally [1]. In Australia, stroke is the third most common cause of death accounting for 75% of all cerebrovascular disease related deaths [2]. Improved outcomes from stroke have been demonstrated from early medical assessment and treatment with resultant implications for both public education and service provision [3]. Current guidelines recognise the benefits of acute stroke care and the need to minimise delays to arrival in the emergency department (ED) and to reduce in-hospital delays [4]. The Australian Stroke Coalition recommends a comprehensive model of care that includes: timely assessment in the ED for acute stroke patients i.e. to be seen by treating physician within 10 min of presentation; the use of a validated stroke screen tool; urgent access to imaging; a system to notify thrombolysis services to decrease ‘door to needle’ time; and the

monitoring of stroke related performance metrics [5]. Further to this, Australian National Emergency Access Targets (NEAT) recommend all patients presenting to ED are discharged, admitted or transferred within four hours of presentation [6].

A rise in the prevalence of stroke is predicted in Australia together with an increased burden of stroke based on the aging population [7]. Further to this, Lowthian et al. [8] reported ED attendances are increasing at rates up to 7% annually, well above that explained by population change. In Australia there were approximately 41,398 hospitalisations for acute stroke in 2013 [9]. In 2009–10 almost 85% of all Australian stroke hospitalisations were emergency admissions, reflective of the urgency of care required in management of stroke [10]. Despite the increasing demand on ED and concern regarding the time critical nature of stroke presentations, there is limited current data on stroke presentations to Australian EDs. Specifically there is a lack of information on the number of stroke ED presentations over recent

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<https://doi.org/10.1016/j.ienj.2019.02.007>

Received 12 August 2018; Received in revised form 13 January 2019; Accepted 23 February 2019

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years, the type of stroke (ischaemic, haemorrhagic) and patient and health service outcomes such as timeliness of care to these patients. It is important to understand these parameters to determine if and where improvement in emergency stroke care can be provided. Therefore, the aim of this study was to evaluate stroke presentations to an Australian ED in terms of demographic and clinical characteristics, as well as health service delivery as measured by time performance over a five year period.

## 2. Methods

### 2.1. Study design and setting

An observational study was conducted at a public teaching hospital in South-East Queensland. The ED recorded 91,902 total ED presentations in 2014–5 [11]. Human Research Ethics Committee approval was obtained from the local health service and Griffith University (HREC/14/QPAH/445 and GU 2015/863).

### 2.2. Data source

Data were extracted by a member of the hospital Health Informatics Division. This pertained to routinely collected data from the hospital information systems including Emergency Department Information System (EDIS), Hospital Based Corporate Information System (HBCIS) and the PPM/TII database. Data extracted included demographics, i.e. date of birth and gender, and clinical information, i.e. arrival date and time, mode of arrival, triage priority, date and time seen by treating doctor, departure date and time, departure status, and ED length of stay (LOS) with times represented in minutes.

### 2.3. Inclusion and exclusion criteria

Data was included for all adult (i.e. aged  $\geq 18$  years) presentations made between 1 July 2010 to 30 June 2015 to the ED with an ED discharge diagnosis of stroke as identified by International Statistical Classification of Diseases and Related Health Problems 10th revision codes for cerebral infarction – unspecified (I63.9), intracerebral haemorrhage – atraumatic (I61.9), and subarachnoid haemorrhage – atraumatic (I60.9). The EDIS system only allows a subset of ICD-10 codes to be entered as principal diagnoses so these three codes captured all ED presentations with a diagnosis of cerebral infarction and intracerebral or subarachnoid haemorrhage.

### 2.4. Study outcomes

Study outcomes included time to doctor from arrival, ED LOS, admission rate and death in ED.

### 2.5. Statistical analysis

Analysis was performed according to stroke type (ischaemic = I63.9 and haemorrhagic = I61.9 & I60.9) with data reported as number and percentage for categorical variables and median and interquartile ranges for continuous data. The Australasian Triage Scale (ATS) was utilised which defines the first time of contact with ED staff as arrival time at which the patient is allocated a triage category of 1, 2, 3, 4, or 5 with 1 involving conditions that are immediately life-threatening and 5 less urgent [12]. The ATS has a maximum recommended time of first contact between the patient and treating medical doctor for each triage priority allocation of 1 – immediately, 2 – within 10 min, 3 – within 30 min, 4 – within 60 min, and 5 – within 120 min [12]. Time from arrival to treating doctor seen was used to calculate if patients were seen within their allocated triage priority time. ED LOS was used to determine if individual presentations exceeded the recommended maximum LOS in ED of four hours [6]. Comparisons were made using

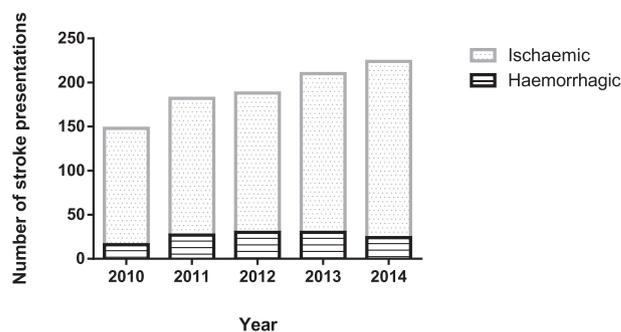


Fig. 1. Number of adult presentations diagnosed with stroke according to year and stroke type.

ordinary analysis of variance through non-parametric measures including Kruskal-Wallis test. Data was analysed using GraphPad Instat Version 3 and graphing performed using GraphPad Prism 6 with a *p*-value below 0.05 considered significant.

## 3. Results

From 2010 to 2015 there was a 51.4% increase in stroke presentations (Fig. 1). Over the five year period, a total of 921 adults made 952 presentations to the ED and were diagnosed with stroke, the majority ( $n = 825$ , 86.7%) were ischaemic rather than haemorrhagic ( $n = 127$ , 13.3%) in nature. Of the 952 presentations, a total of 63 were re-presentations with two presentations by 29 patients for ischaemic stroke and one patient for haemorrhagic stroke, while one patient had three presentations of ischaemic stroke. Table 1 presents the demographic, clinical characteristics and outcomes for patient presentations diagnosed with stroke, by stroke type and sex. Patient presentations with stroke were similar in sex (50.4% male) and median age of all patients was 70 (56–80) years with similar age distributions across genders, i.e. males 69 (55–78) years and females 69 (55–82) years. The majority of patient presentations diagnosed with stroke were allocated triage category of 1 or 2 for both ischaemic (61.6%) and haemorrhagic (70.9%) stroke and majority of all presentations arrived by ambulance (71.0%).

Regarding outcomes for those diagnosed with stroke, most (94.9%) were admitted after a median ED LOS of 318.5 (222–463) minutes. Death in ED occurred for 1.4% of presentations, with haemorrhagic stroke associated with significantly higher mortality than ischaemic stroke (7.9% vs 0.4%,  $p < 0.0001$ ). The median age of presentations resulting in mortality was significantly higher than those who survived (80 vs 69 years,  $p = 0.0103$ ).

Changes over time for patients diagnosed with stroke were noted (see Table 2). All presentations categorised as ATS 1 were seen immediately and there was a decrease in the number of presentations categorised as ATS 2 that were seen outside the maximum specified time frame for that category, i.e. 10 min. There was also a significant decrease in median LOS in ED for both haemorrhagic (435 to 215 min,  $p < 0.05$ ) and ischaemic (451 to 238 min,  $p < 0.001$ ) stroke (Fig. 2) and there was a significant decrease in the number of patients with a stay in ED greater than four hours for haemorrhagic (82.4% to 44%,  $p < 0.05$ ) and ischaemic (92.4% to 45.8%,  $p < 0.0001$ ) stroke (Fig. 3).

## 4. Discussion

Stroke is a leading cause of death and disability with an increasing trend of stroke presentations attending the ED [13]. There is limited data on ED stroke presentations in Australia and therefore the aim of this study was to describe stroke presentations to an ED in South-East Queensland Australia. This study found that despite an increase in

**Table 1**  
Demographic, clinical characteristics, and outcomes for adult presentations diagnosed with stroke according to stroke classification and gender.

	Ischaemic stroke n = 825 (86.7)		Haemorrhagic stroke n = 127 (13.3)	
	Female	Male	Female	Male
Presentations	404 (49.0)	421 (51.0)	68 (53.5)	59 (46.5)
Age	71 (55–82)	69 (56–79)	66 (51–80.5)	63 (52–75)
<i>Triage Priority</i>				
1	30 (7.4)	37 (8.8)	18 (26.5)	11 (18.7)
2	216 (53.5)	225 (53.5)	31 (45.6)	30 (50.8)
3	150 (37.1)	153 (36.3)	18 (26.5)	17 (28.8)
4	8 (2.0)	6 (1.4)	1 (1.4)	1 (1.7)
Ambulance arrival	279 (69.1)	290 (68.9)	56 (82.4)	51 (86.4)
Admitted	382 (94.6)	407 (96.7)	59 (86.8)	55 (93.2)
Time to doctor	15.5 (6–40)	14 (5–41.75)	6.5 (0–29)	8 (1–36)
Length of stay in ED	335 (238.5–473.8)	308 (215.5–459)	267.5 (171.5–400.3)	317 (203–643)
Died in ED	2 (0.5)	1 (0.2)	7 (10.3)	3 (5.1)

Data represented is median (25th and 75th percentile) for age (years), time to doctor (minutes), and length of stay in ED (minutes), and number (percentage) for all other categories.

stroke presentations over the five year period there was a trend towards improvements in most outcomes studied.

This study found a 51% increase in stroke presentations from 2010 to 2015. Similar to this, Feigin et al. [14] report that globally the absolute number of people affected by both ischaemic and haemorrhagic stroke has increased significantly over time. In contrast, a decreasing stroke incidence has been reported in Australian studies from other states including Victoria [15,16], Western Australia [17], and South Australia [18,19]. The study site ED recorded 91,902 total ED presentations in 2014–5 and 83,015 in 2013–14 [11], so over these years the percentage of stroke presentations relative to all ED presentations

remained stable at 0.25%. Reduction or stabilisation of stroke incidence in developed countries has been associated with good health care and strategies for stroke prevention [20], increased use of medication for treatment of stroke risk factors [21], and a declining prevalence of smoking [22]. The majority of stroke presentations were ischaemic (86%) but there was a significantly higher mortality with haemorrhagic stroke. Similarly, Ayala et al. [23] reported that 70–80% of all strokes were ischaemic but haemorrhagic strokes have a higher mortality. Further to this, Persky et al. [24] found women over the age of 85 years have a higher stroke incidence and mortality than age-matched men. This is comparable to our study in which median age of presentations

**Table 2**  
Demographic, clinical characteristics, and outcomes for adult ED presentations made between 2010 and 2015 diagnosed with stroke according to stroke classification.

	Haemorrhagic 160.9 Subarachnoid Haemorrhage – Atraumatic and 161.9 Intracerebral Haemorrhage – Atraumatic					Ischaemic 163.9 Cerebral Infarction – Unspecified				
	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015
Age	73 (57–77)	61 (50–81)	67 (46–80)	56 (44–76)	67 (56–77)	71 (56–82)	74 (59–81)	67 (55–77)	70.5 (56–80)	67 (53–83)
<i>Gender</i>										
Male	6 (37.5)	18 (66.7)	8 (26.7)	14 (46.7)	13 (54.2)	73 (55.3)	72 (46.5)	82 (51.9)	87 (48.3)	107 (53.5)
Female	10 (62.5)	9 (33.3)	22 (73.3)	16 (53.3)	11 (45.8)	59 (44.7)	83 (53.5)	76 (48.1)	93 (51.7)	93 (46.5)
<i>Arrival Mode</i>										
Ambulance	15 (93.8)	20 (74.1)	25 (83.3)	25 (83.3)	22 (91.7)	93 (70.5)	105 (67.7)	115 (72.8)	121 (67.2)	135 (67.5)
Walk in/other	1 (6.2)	7 (25.9)	5 (16.7)	5 (16.7)	2 (8.3)	39 (29.5)	50 (32.3)	43 (27.2)	59 (32.8)	65 (32.5)
<i>Triage Priority</i>										
1	4 (25.0)	4 (14.8)	6 (20.0)	6 (20.0)	9 (37.5)	9 (6.8)	13 (8.4)	6 (3.8)	13 (7.2)	26 (13.0)
2	9 (56.3)	15 (55.6)	13 (43.3)	12 (40.0)	12 (50.0)	71 (53.8)	83 (53.5)	84 (53.2)	95 (52.8)	108 (54.0)
3	3 (18.7)	7 (25.9)	11 (36.7)	11 (36.7)	3 (12.5)	50 (37.9)	58 (37.5)	64 (40.5)	67 (37.2)	64 (32.0)
4	0 (0.0)	1 (3.7)	0 (0.0)	1 (3.3)	0 (0.0)	2 (1.5)	1 (0.6)	4 (2.5)	5 (2.8)	2 (1.0)
Time to doctor	11 (1–44)	7 (1–27)	6 (1–15)	8 (0–53)	4 (0–24)	22 (6–52)	11 (4–30)	12 (5–36)	15.5 (6–47)	16 (5–46)
<i>Time to doctor &gt; triage priority</i>										
1	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
2	5 (55.6)	3 (18.8)	1 (7.1)	2 (16.7)	3 (25.0)	43 (60.6)	28 (33.7)	23 (27.1)	34 (35.8)	56 (51.4)
3	2 (66.7)	3 (42.8)	6 (54.5)	7 (63.6)	3 (10.0)	36 (72.0)	33 (56.9)	40 (62.5)	41 (61.2)	43 (67.2)
4	NA	0 (0.0)	NA	0 (0.0)	NA	1 (50.0)	0 (0.0)	1 (25.0)	4 (80.0)	1 (50.0)
LOS in ED	435 (307–614)	290 (233–475)	279 (191–387)	250 (143–512)	215 (147–343)	451 (350–666)	372 (269–542)	328 (230–475)	281 (216–414)	238 (195–342)
LOS > 4hrs	14 (82.4)	19 (70.4)	20 (64.5)	15 (50.0)	11 (44.0)	122 (92.4)	128 (82.6)	114 (72.2)	109 (60.6)	92 (45.8)
<i>Outcome</i>										
Died in ED	1 (6.2)	3 (11.1)	4 (13.4)	2 (6.7)	0 (0.0)	1 (0.8)	0 (0.0)	1 (0.7)	1 (0.5)	0 (0.0)
Admit	15 (93.8)	23 (85.2)	25 (83.3)	27 (90.0)	24 (100)	124 (93.9)	146 (94.2)	150 (94.9)	174 (96.7)	195 (97.5)
Discharged	0 (0.0)	1 (3.7)	1 (3.3)	1 (3.3)	0 (0.0)	7 (5.3)	9 (5.8)	7 (4.4)	5 (2.8)	5 (2.5)

Data represented is median (25th and 75th percentile) for age (years), time to doctor (minutes), and length of stay in ED (minutes), and number (percentage) for all other categories NA = not applicable.

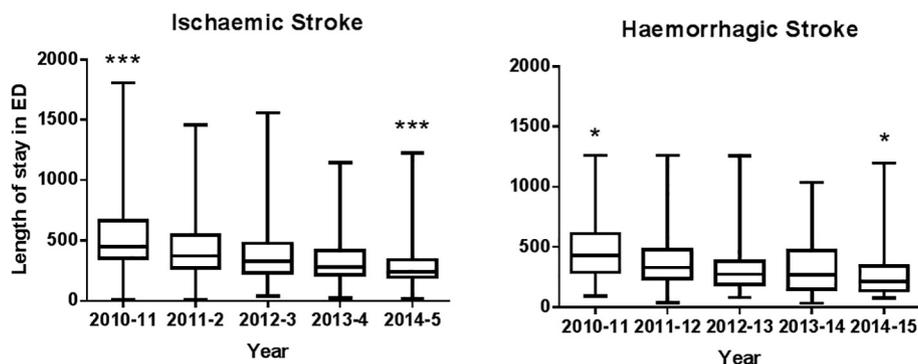


Fig. 2. Length of stay in emergency department (minutes) according to year for both ischaemic and haemorrhagic stroke. The box represents the median, 25th and 75th percentile and the whiskers the minimum and maximum values with statistical significance represented by \*p < 0.05 and \*\*\*p < 0.001.

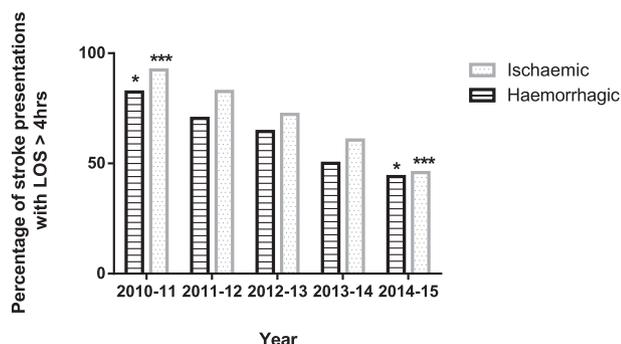


Fig. 3. Percentage of presentations with length of stay in emergency department greater than four hours according to year and stroke type with statistical significance represented by \*p < 0.05 and \*\*\*p < 0.0001.

resulting in mortality was 80 and stroke incidence increased with age with women over the age of 80 having a higher incidence than men of this age (data not shown). Stroke mortality has been associated with not only age and gender but also stroke severity and patient co-morbidities [25]. This study did not investigate patient variables which may have impacted mortality and thus the higher mortality seen in females aged over 80 in this study cannot be fully explained.

Timely care for people arriving to the ED with stroke is paramount as early treatment provides more favourable outcomes [26]. Australian recommendations are for stroke patients to be seen within 10 min of presentation [5] which corresponds to a triage category of 1 or 2. In our study 71% of presentations arrived by ambulance and 63% of presentations were allocated the ATS category of 1 or 2. In comparison, Mosley et al. [27] assessed stroke presentations to three EDs in Melbourne and found 89% arrived by ambulance and 71% were allocated an urgent triage category, i.e. 1 or 2. Further to this, these authors found patients with facial weakness or speech problems were more likely to be correctly triaged, whilst patients with loss of co-ordination or resolving symptoms were less likely to be allocated an ATS of 1 or 2 [27]. Ro et al. [28] found appropriate triage based allocation followed by clinical treatment protocols can decrease mortality and decrease ED LOS for patients. The signs and symptoms of stroke may be difficult to detect, particularly at the point of triage given the variable presentation and stroke mimics, as evidenced by the finding that one third of patients were allocated an ATS category 3 and 4. This finding warrants further exploration to understand the reasoning for categorisation of stroke presentations into ATS 3 or 4 plus the resultant impact on clinical and patient outcomes. One possible explanation is that the presenting symptoms of the patient resulted in a lack of recognition of possible stroke and subsequent mis-coding of the presentation to a lower ATS category. This study did not correlate presenting symptoms with ATS category thus limiting the ability to fully explain the number of patients under-triaged for stroke. Travers et al. [29] reported five level triage

systems to have less likelihood to under-triage patients due to greater reliability and discrimination than three level triage systems. The ATS is a five level system and a meta-analysis by Ebrahimi et al. [30] demonstrated that the ATS showed an acceptable level of reliability to allocate patients to appropriate categories with a high rate (78.6%) of agreement among raters. Previous recommendations to evaluate consistency of the ATS have included review of waiting times, admission rates, triage nurse education, and chart audit of triage documentation [31]. This study evaluated two of the recommended indicators of the ATS in ED, namely admission rates and wait times for stroke presentations given the importance of time in the management of stroke. However, further study including review of medical records is required to fully evaluate the care of stroke presentations in the ED and correctly implement strategies to improve triage of stroke presentations and outcomes for patients.

Prolonged ED LOS (> 300 min) has been shown to result in worsened outcomes for patients with stroke [32]. Our study found there was an overall decrease in ED LOS for stroke presentations over the five year period to a median of 215 min for haemorrhagic stroke and 238 min for ischaemic stroke. Comparable to this, Goluke et al. [33] reported a median ED LOS of 243 min for elderly patients but significantly shorter LOS with neurology admissions. Over the five years in our study, compliance with the proportion of patients discharged from the ED within four hours increased with around 55% of patients having a LOS in ED less than four hours in 2014–15. Whilst it is recognised that compliance with NEAT in Australia results in reduced in-hospital mortality of ED admissions, this is only apparent with NEAT compliance rates of 65% for admitted patients [34]. Staib et al. [35] reports a 52.9% compliance with the four hour rule for admitted patients to all Queensland public hospitals in 2013–14 but explains that these patients are often more complex patients requiring greater integration of hospital processes with potentially more to gain from appropriate timely care. Akhtar et al. [36] associated delays in transferring stroke patients from the ED to increased risk of complication, slower recovery, and increased risk of mortality. Whilst our study did not directly measure mortality and morbidity with time targets, it may be that the improved time to doctor and reduced LOS in ED would result in improved outcomes for the stroke presentations.

Other models to support the assessment and management of stroke in the ED and hospital setting that have been shown to positively impact patient outcomes include accurate paramedic diagnosis with rapid hospitalisation [37], and organised stroke unit care [38]. Emergency departments with systems to activate involvement by acute stroke teams have demonstrated improved time to evaluation, time to treatment, and a reduction in ED LOS [39,40]. At the site of this study, the ED and neurology team conducted a simulation which demonstrated improved door to needle/thrombolysis time with a co-ordinated stroke team response and highlighted the need for a formalised process to be implemented. In August 2014, a ‘Stroke Code’ was initiated which

activates an immediate response from the Neurology service by a team consisting of a stroke clinical nurse consultant and stroke registrar and who liaise with the stroke consultant. The service is altered out of hours with the night shift Medical Registrar liaising directly with the on-call Neurology consultant regarding treatment options. This change may have impacted results in the final year of this study but additional investigation is required to determine if the implementation of the stroke code further improves time performance or results in different outcomes for patients when activated.

This study has demonstrated improvement in multiple time performance measures routinely collected such as LOS and performance according to allocated triage. Monitoring process measures is important but future time performance studies should investigate time data focusing on clinical measures of care delivery such as radiology and thrombolysis. Correlating patient factors such as symptom onset and stroke severity to triage allocation and outcomes would further assist interpretation of data and allow identification of areas for quality improvement. Investigating all aspects of patient care in the ED from triage to discharge can potentially minimise treatment delays and target quality improvement measures to optimise management of stroke presentations.

## 5. Limitations

Limitations of this study are that it is a single site retrospective study and uses routinely collected data that is designed primarily for clinical and reporting purposes. Whilst there is the possibility for errors in the data (including diagnosis used to define our study groups) staff are trained in data entry and its importance. We did not include care delivery provided for patients with stroke in the ED such as the use of and time to radiology or other recommendations from the Stroke Foundation including assessment via a validated stroke screening tool or admission to stroke units, limiting our ability to further explain or discuss findings.

## 6. Conclusion

Although the numbers of stroke presentations to an Australian ED increased over time, there were improvements over time in multiple performance targets including time to doctor, LOS in ED, and percentage of patients with a LOS in ED less than four hours. Monitoring time-based targets is particularly important for people presenting to the ED with stroke given the time critical nature of stroke management. Further optimising processes of care, particularly at the point of triage to enhance recognition and prompt management of stroke, may improve outcomes for stroke patients.

## References

- Feigin VL, Norrving B, Mensah GA. Global burden of stroke. *Circ Res* 2017;120(3):439–48.
- Economic impact of stroke in Australia: Deloitte Access Economics; 2013 [Available from: <https://strokefoundation.org.au/What-we-do/Research/Economic-impact-of-stroke-in-Australia>].
- Rothwell PM, Giles MF, Chandratheva A, Marquardt L, Geraghty O, Redgrave JN, et al. Effect of urgent treatment of transient ischaemic attack and minor stroke on early recurrent stroke (EXPRESS study): a prospective population-based sequential comparison. *Lancet* 2007;370(9596):1432–42.
- Evenson KR, Rosamond WD, Morris DL. Prehospital and in-hospital delays in acute stroke care. *Neuroepidemiology* 2001;20(2):65–76.
- 48 hours: Improving stroke management in the critical window: Australian Stroke Coalition; 2014 [Available from: <http://australianstrokecoalition.com.au/site/media/ASC-48-hour-paper-March-2014.pdf>].
- Australian Hospital statistics: national emergency access and elective surgery Australian Institute of Health and Welfare; 2012 [Available from: <https://www.aihw.gov.au/reports/hospitals/australian-hospital-statistics-national-emergency/contents/summary>].
- Clissold BB, Sundararajan V, Cameron P, McNeil J. Stroke incidence in Victoria, Australia—emerging improvements. *Front Neurol* 2017;8.
- Lowthian JA, Curtis AJ, Cameron PA, Stoelwinder JU, Cooke MW, McNeil JJ. Systematic review of trends in emergency department attendances: an Australian perspective. *Emergency Med J* 2010. 099226.
- Kim J, Andrew NE, Thrift AG, Bernhardt J, Lindley RJ, Cadilhac DA. The potential health and economic impact of improving stroke care standards for Australia. *Int J Stroke* 2017. 1747493017700662.
- Australian-Government. Stroke and its management in Australia: an update. Canberra: Australian Institute of Health and Welfare; 2013.
- Time spent in hospitals and emergency departments: Australian Government; [Available from: <https://www.myhospitals.gov.au/hospital/310000050/gold-coast-university-hospital/emergency-department>].
- Guidelines on the implementation of the Australasian Triage Scale in Emergency Departments: Australasian College for Emergency Medicine; [Available from: <https://acem.org.au/getattachment/4320524e-ad60-4e7c-a96d-bd90cd7966c/G24-Implementation-of-the-Australasian-Triage-Scale.aspx>].
- Aksoy D, Ayan M, Alatlı T, Sahin F, Özdemir MB, Çevik B, et al. Clinical and demographic properties of the acute stroke patients admitted to Emergency Department of a Tertiary Referral Center. *J Acad Emerg Med* 2014;13(3):135.
- Feigin VL, Krishnamurthi RV, Parmar P, Norrving B, Mensah GA, Bennett DA, et al. Update on the global burden of ischemic and hemorrhagic stroke in 1990–2013: the GBD 2013 study. *Neuroepidemiology* 2015;45(3):161–76.
- Thrift AG, Dewey HM, Macdonell RA, McNeil JJ, Donnan GA. Stroke incidence on the East Coast of Australia. *Stroke* 2000;31(9):2087–92.
- Christie D. Stroke in Melbourne, Australia: an epidemiological study. *Stroke* 1981;12(4):467–9.
- Islam MS, Anderson CS, Hankey GJ, Hardie K, Carter K, Broadhurst R, et al. Trends in incidence and outcome of stroke in Perth, Western Australia during 1989 to 2001. *Stroke* 2008;39(3):776–82.
- Leyden JM, Kleinig TJ, Newbury J, Castle S, Cranefield J, Anderson CS, et al. Adelaide stroke incidence study. *Stroke/Strokeaha* 2013;113.675140.
- Newbury J, Kleinig T, Leyden J, Arima H, Castle S, Cranefield J, et al. Stroke epidemiology in an Australian Rural Cohort (SEARCH). *Int J Stroke* 2017;12(2):161–8.
- Feigin VL, Forouzanfar MH, Krishnamurthi R, Mensah GA, Connor M, Bennett DA, et al. Global and regional burden of stroke during 1990–2010: findings from the Global Burden of Disease Study 2010. *Lancet* 2014;383(9913):245–55.
- Wieberdink RG, Ikram MA, Hofman A, Koudstaal PJ, Breteler MM. Trends in stroke incidence rates and stroke risk factors in Rotterdam, the Netherlands from 1990 to 2008. *Eur J Epidemiol* 2012;27(4):287–95.
- Thiele I, Linseisen J, Heier M, Holle R, Kirchberger I, Peters A, et al. Time trends in stroke incidence and in prevalence of risk factors in Southern Germany, 1989 to 2008/09. *Sci Rep* 2018;8(1):11981.
- Ayala C, Croft JB, Greenlund KJ, Keenan NL, Donehoo RS, Malarcher AM, et al. Sex differences in US mortality rates for stroke and stroke subtypes by race/ethnicity and age, 1995–1998. *Stroke* 2002;33(5):1197–201.
- Persky RW, Turtzo LC, McCullough LD. Stroke in women: disparities and outcomes. *Curr Cardiol Rep* 2010;12(1):6–13.
- 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(8):345–50.
- Marler JR, Tilley B, Lu M, Brott TG, Lyden P, Grotta J, et al. Early stroke treatment associated with better outcome the NINDS rt-PA stroke study. *Neurology* 2000;55(11):1649–55.
- Mosley I, Morphet J, Innes K, Braitberg G. Triage assessments and the activation of rapid care protocols for acute stroke patients. *Austral Emerg Nurs J* 2013;16(1):4–9.
- Ro YS, Shin SD, Song KJ, Cha WC, Cho JS. Triage-based resource allocation and clinical treatment protocol on outcome and length of stay in the emergency department. *Emerg Med Austral* 2015;27(4):328–35.
- Travers DA, Waller AE, Bowling JM, Flowers D, Tintinalli J. Five-level triage system more effective than three-level in tertiary emergency department. *J Emerg Nurs* 2002;28(5):395–400.
- Ebrahimi M, Heydari A, Mazlom R, Mirhaghi A. The reliability of the Australasian Triage Scale: a meta-analysis. *World J Emerg Med* 2015;6(2):94.
- Monash Institute of Health Services Research. Consistency of triage in Victoria's emergency departments: triage consistency report. Clayton, Vic: Monash Institute of Health Services Research; 2001.
- Jones EM, Boehme AK, Aysenne A, Chang T, Albright KC, Burns C, et al. Prolonged emergency department length of stay as a predictor of adverse outcomes in patients with intracranial hemorrhage. *J Crit Care Med* 2015;2015.
- Golüke N, Huibers C, Stalpers S, Taekema D, Vermeer S, Jansen P. An observational, retrospective study of the length of stay, and its influencing factors, among elderly patients at the Emergency Department. *Eur Geriatric Med* 2015;6(4):331–5.
- Sullivan C, Staib A, Khanna S, Good NM, Boyle J, Cattell R, et al. The National Emergency Access Target (NEAT) and the 4-hour rule: time to review the target. *Med J Australia* 2016;204(9):354.
- Staib A, Sullivan C, Griffin B, Bell A, Scott I. Report on the 4-h rule and National Emergency Access Target (NEAT) in Australia: time to review. *Australian Health Rev* 2016;40(3):319–23.
- Akhtar N, Kamran S, Singh R, Cameron P, Bourke P, Khan R, et al. Prolonged stay of stroke patients in the emergency department may lead to an increased risk of complications, poor recovery, and increased mortality. *J Stroke Cerebrovasc Dis* 2016;25(3):672–8.
- Wojner-Alexandrov AW, Alexandrov AV, Rodriguez D, Persse D, Grotta JC. Houston paramedic and emergency stroke treatment and outcomes study (HoPSTO). *Stroke* 2005;36(7):1512–8.
- Trialsists/Collaboration SU. Organised inpatient (stroke unit) care for stroke. *Cochrane Database System Rev*; 2001.
- Nazir F, Petre I, Dewey HM. Introduction of an acute stroke team: an effective approach to hasten assessment and management of stroke in the emergency department. *J Clin Neurosci* 2009;16(1):21–5.
- Hamidon B, Dewey HM. Impact of acute stroke team emergency calls on in-hospital delays in acute stroke care. *J Clin Neurosci* 2007;14(9):831–4.