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Research paper

Improving stroke Emergency Department nursing care: The Code Stroke 2.0 pre-test/post-test feasibility study

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ABSTRACT

Background: Activation of an acute 'Code Stroke' pathway on hospital arrival improves thrombolysis rates. Whilst post-stroke protocols to manage fever, hyperglycaemia, and dysphagia (Fever, Sugar and Swallow (FeSS) Protocols) have been shown to reduce death and dependency, facilitated implementation in Emergency Department (ED) has been difficult.
Aim: To evaluate if an expanded role for an Acute Stroke Nurse improves Code Stroke activation, increases FeSS Protocol uptake in ED, and results in faster stroke unit transfer.
Methods: A pre-test/post-test feasibility study undertaken in an Australian ED. Intervention comprised an expanded Acute Stroke Nurse role who instigated FeSS Protocol care or supported ED clinicians to use the protocols. Logistic regression analyses compared outcomes pre-test/post-test intervention. Subgroup analysis examined intervention effect during business hours.
Findings: There were 117 patients each in the pre-intervention and post-intervention cohorts (n = 234). Post-intervention patients had significantly more Code Stroke activations (pre: 7%, post: 62%), temperature at ED arrival (pre: 62%, post: 78%), formal blood glucose (pre: 55%, post: 98%), fewer oral medications administered before swallow screening (pre: 31%, post: 14%), more stroke unit transfers within 4 h from ED arrival (pre: 26%, post: 41%), and thrombolysis screening (pre: 53%, post: 80%). Subgroup analysis during business hours showed significant improvement in Code Stroke activations (pre: 10%, post: 79%), formal blood glucose testing (pre: 57%, post: 98%), reduced oral medications before swallow screening (pre: 24%, post: 9%), and thrombolysis screening (pre: 45%, post: 82%).
Conclusion: Expanding the Acute Stroke Nurse role to support ED staff during Code Stroke was associated with improved stroke care processes. Our findings highlight potential for successful implementation of this model across multiple hospitals to improve patient outcomes.

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Summary of relevance
Problem or Issue
Research is needed on effective models of care to facilitate implementation of proven stroke interventions such as the Fever, Sugar and Swallow (FeSS) Protocols in the Emergency Department.
What is already known
Code Stroke systems help expedite acute stroke treatment in the Emergency Department and Acute Stroke Nurses are actively involved in the process.
What this paper adds
An expanded Acute Stroke Nurse role to respond to Code Stroke activations within the Emergency Department improved Code Stroke activations and use of evidence-based FeSS Protocols. Emergency Department length of stay was reduced with rapid admission to the stroke unit.

1. Introduction

Stroke is a leading cause of morbidity and mortality internationally (Feigin et al., 2021), including Australia, where it is the third leading cause of death (Australian Institute of Health and Welfare, 2018). As the population ages, prevalence of stroke within the Australian community continues to rise (Deloitte Access Economics, 2020). Management of stroke has improved significantly over the last 20 years with the advent of stroke unit care. Organised inpatient management on stroke units has been shown to be effective in reducing morbidity and mortality following stroke (Langhorne, Ramachandra, & Stroke Unit Trialists' Collaboration, 2020). Hence, timely transfer of patients with acute stroke to the stroke unit is of utmost importance for optimal patient outcomes (Busingye et al., 2018).

Coordinated stroke care by specialised staff using appropriate pathways and protocols is important in the management and prevention of post-stroke sequelae for stroke patients (Middleton et al., 2011). The Fever, Sugar and Swallow (FeSS) Protocols are nurse-initiated interventions for acute stroke patients for managing hyperthermia (≥37.5°), hyperglycaemia (> 10 mmol/L), and screening for dysphagia. The Quality in Acute Stroke Care (QASC) Trial demonstrated that facilitated implementation of the FeSS Protocols in stroke units improved patient morbidity and mortality (Middleton et al., 2011), and long-term survival on follow-up for a median of four years (Middleton et al., 2017).

A subsequent cluster randomised controlled trial (Triage, Treatment, and Transfer (T^3) Trial) evaluated the introduction and uptake of the FeSS Protocols as part of evidence-based stroke care in Australian Emergency Departments (EDs) (Middleton et al., 2016). However, despite using proven implementation science strategies (multidisciplinary workshops, education programs for clinicians, clinical champions, reminders, and action plan mapping with trial coordinators), the T^3 Trial did not demonstrate improved outcomes for stroke patients or effect change in stroke processes of care. Potential reasons included complex barriers related to the dynamic ED setting (Middleton et al., 2019), clinician beliefs about the evidence and professional boundaries (McInnes et al., 2020). Similarly, evidence from another international study examining the implementation of a nursing-administered stroke care improvement intervention in the ED also highlighted as barriers high-volume patient load and limited staffing (Daniels, Anderson, & Petersen, 2013). As many stroke patients first present to the ED, it is necessary to develop effective models of care to facilitate prompt delivery of evidence-based stroke care for optimal patient outcomes.

'Code Stroke' systems are widely implemented internationally to expedite acute stroke treatment in the ED (Nouh et al., 2022; Sung & Tseng, 2014). The Code Stroke response consists of pre-notification of the stroke team by ambulance services, including neurology and stroke nursing staff, to the impending hospital arrival of a patient with suspected stroke. Australian and international studies have demonstrated benefits of the Code Stroke system in reducing door-to-needle times and increasing thrombolysis rates (Chen et al., 2014; De La Ossa et al., 2008; Meretoja et al., 2013; Tai, Weir, Hand, Davis, & Yan, 2012). The Code Stroke response is firmly centred around the assessment and subsequent relevant provision of thrombolysis therapy (Tai et al., 2012). However, there is potential within Code Stroke to also facilitate implementation of proven stroke interventions such as the FeSS Protocols in the ED.

Acute Stroke Nurses facilitate the delivery of evidence-based acute stroke care within a stroke unit (Middleton et al., 2011). Besides receiving additional postgraduate qualifications in stroke management, nurses in this role typically have extensive experience working in a stroke unit. They are also actively involved in responding to Code Stroke activations, where they assist with thrombolysis administration, expedition of neuroimaging procedures and prompt admission to the stroke unit (Park et al., 2021). Given their knowledge and experience in acute stroke care as well as management of the Code Stroke pathway, they are well placed to support delivery of the FeSS Protocols within Code Stroke. Hence, there is potential to expand the role of the Acute Stroke Nurse to include provision of evidence-based nursing interventions such as the FeSS Protocols to acute stroke patients on presentation to the ED. Given the complexities of the ED setting, which were identified in the T^3 Trial as barriers to implementation of the FeSS Protocols, an evaluation of a novel model of care involving an expanded role for the Acute Stroke Nurse within Code Stroke in the ED is warranted.

The Code Stroke 2.0 feasibility study aimed to evaluate if an expanded role for the Acute Stroke Nurse as part of current Code Stroke practices (i) improved Code Stroke activation, (ii) increased FeSS protocol uptake in the ED, and (iii) facilitated prompt stroke unit transfer. The delivery of timely acute stroke care in the ED before admitting a patient to the stroke unit is vital for improved patient outcomes. If an evaluation of this model of care is shown to improve stroke care processes in the ED, there is the potential for national and global translation with subsequent improvement in patient outcomes.

2. Methods

The design was a single-centre pre-test/post-test feasibility study using independent samples.

2.1. Setting

The study was undertaken in one ED of a large tertiary referral teaching hospital with an acute stroke unit in an Australian capital city.

2.2. Patient eligibility and data collection

All consecutive stroke patients admitted to the ED aged ≥18 years and who presented less than 48 h from symptom onset were eligible for inclusion. Patients were excluded if their admission was for primarily palliative care. Patient data for this study were obtained from electronic health records. Pre-intervention patient data were obtained from a retrospective medical record audit of patients at the study site in the T^3 Trial post-intervention cohort recruited between November 2015 and September 2016 using opt-out consent (Middleton et al., 2016, 2019). For the post-intervention cohort, the medical records of eligible patients admitted between August 2018 and April 2019 were audited using a waiver of consent process. As the pre-intervention patient audit data were obtained from patients

Box 1
Fever, Sugar and Swallow Protocols

1. Fever	a. Recording of an admission temperature on arrival (within 60 min) and ongoing temperature recording every 4 h.
	b. If a patient's temperature is ≥37.5 °C, facilitate administration of 1 g of paracetamol by an appropriate route.
2. Sugar	a. Obtaining a venous blood glucose level (within 60 min) to be sent to the laboratory.
	b. Recording of an admission finger-prick blood glucose (within 60 min) and alert medical staff if corrective action required (order and administer insulin if blood glucose level > 10 mmol/L) with ongoing blood glucose management every six hours.
3. Swallow	a. Completion of an Acute Screening of Swallow in Acute Stroke/Transient Ischemic Attack swallow screen. If the patient fails the screen, the Acute Stroke Nurse makes the patient nil by mouth and refers to speech pathologist for formal assessment.
	b. No oral intake (food, drink or oral medications) given until cleared by screening or assessed by a speech pathologist.

recruited in the T^3 Trial at the study site, the same number of patients were audited for the post-intervention cohort given that this was a feasibility study.

The T^3 Trial data that informed the pre-intervention patient data for this study were collected by an independent outcome assessor blinded to study aim, design, and group allocation. Following the eight-month intervention period, the medical records of all eligible patients were reviewed in an identical manner but by an unblinded data collector to obtain the post-intervention patient data. Data on patient demographic characteristics (age, sex) and clinical characteristics, including stroke severity (National Institutes of Health Stroke Scale score), all temperature and blood glucose readings, swallowing screening, Code Stroke activations, premorbid modified Rankin Scale, stroke time of onset/last time seen well, eligibility and receipt of thrombolysis, endovascular clot retrieval and ED, and hospital length of stay, were obtained for both cohorts using identical methods.

2.3. Intervention

The FeSS Protocols were developed by a multidisciplinary panel of experts and informed by evidence-based clinical practice guidelines (Middleton et al., 2011). They are recommended best practice in clinical guidelines for stroke (Stroke Foundation, 2019) (Box 1). The FeSS Protocols were implemented by the Acute Stroke Nurse in the ED commencing November 2017.

Only three nurses provided the intervention, one existing full-time Acute Stroke Nurse and two other (1.8 full-time equivalent) newly recruited Acute Stroke Nurses, from Monday to Friday 0800–2100, weekends and public holidays 0800–1630 for 365 days of the year. The Acute Stroke Nurses were trained by one of the researchers (BJ), utilising one-on-one education sessions, readings and hands-on clinical exposure before commencing their roles. Their role in the Code Stroke 2.0 study consisted of reviewing stroke patients in the ED to ensure that patients had been appropriately assessed for thrombolysis eligibility, baseline temperature, and blood glucose readings had been taken, action taken to treat fever or hyperglycaemia and brain imaging had been completed. If the patient was eligible for thrombolysis and so ordered by the treating neurologist, the Acute Stroke Nurse on duty would administer treatment or support ED staff to do so.

Following administration of thrombolysis or if it was not required, the Acute Stroke Nurse would provide facilitation of the uptake and documentation of the FeSS Protocols, by either working with the ED nurses or completing protocol tasks themselves (Box 1). All patients were routinely 'Nil by Mouth' and only after determination of potential acute treatment a swallow screen would be completed, to avoid patients who may potentially require endovascular treatment being given oral intake. The Acute Stroke Nurses also worked with the ED nurses to reduce ED length of stay with a goal of stroke unit admission within 4 h of ED arrival. The enhanced role of the Acute Stroke Nurse is summarised in Fig. 1.

2.4. Implementation of the intervention

The evidence-based strategy (Box 2) for implementing the FeSS Protocols was based on those used in the QASC Trial (Middleton et al., 2011). First, a clinical champion (who was an ED Staff Specialist) was identified to drive clinical change in the ED working collaboratively with the Acute Stroke Nurses (Flodgren, O'Brien, Parmelli, & Grimshaw, 2019). Two interactive and didactic education sessions for nurses and doctors in the ED and stroke unit nurses were then conducted by an Acute Stroke Nurse explaining the intervention (Forsetlund et al., 2021). This included a brief PowerPoint presentation delivered to ED clinicians and stroke unit nurses collectively. These sessions aimed to educate ED clinicians and stroke unit nurses about the elements of the FeSS Protocols with an emphasis on activating calls early from triage (or prehospital where appropriate). Sessions were conducted at handover times to maximise attendance. The Acute Stroke Nurse was also available for any additional education sessions requested by ED if required.

Reminders aimed at sustained engagement of ED and stroke unit clinicians were also used throughout the study (Grimshaw et al., 2004). This consisted of verbal reminders at ED medical and nursing handovers to encourage Code Stroke activations to come through to the Acute Stroke Nurse. In addition, email and telephone support were provided by the Acute Stroke Nurse. Last, Code Stroke activation data were fed back to the Head of Neurology and the Head of the ED on a six-weekly basis, consisting of (i) the number of Code Stroke calls received by the Acute Stroke Nurse; and (ii) potential Code Stroke calls that were missed (Ivers et al., 2012). When appropriate, this information was also provided in email newsletters to ED nursing and medical mailing lists. No other process of care data (e.g., FeSS Protocol adherence) was fed back to the clinicians throughout the study period.

2.5. Outcome measures

The primary outcome was whether or not patients with suspected stroke had a Code Stroke call activated on ED arrival. Secondary outcomes comprised whether or not each of the FeSS processes of care were undertaken in the ED (Box 1), and stroke unit admission within 4 h of ED arrival. Given that our intervention had the potential to influence subsequent stroke unit care, additional post hoc tertiary outcomes were whether or not each of the FeSS processes of care for fever, hyperglycaemia, and dysphagia management were undertaken in the stroke unit.

2.6. Data analysis

Data were analysed using the R version 3.6.1 statistical package (R Foundation for Statistical Computing: Vienna, Austria) (R Core Team, 2019). Continuous data were reported as mean and standard deviation or median and quartiles (Q1 and Q3), depending on the distribution of the data. Categorical data were reported as frequencies and percentages. Demographic, clinical characteristics of

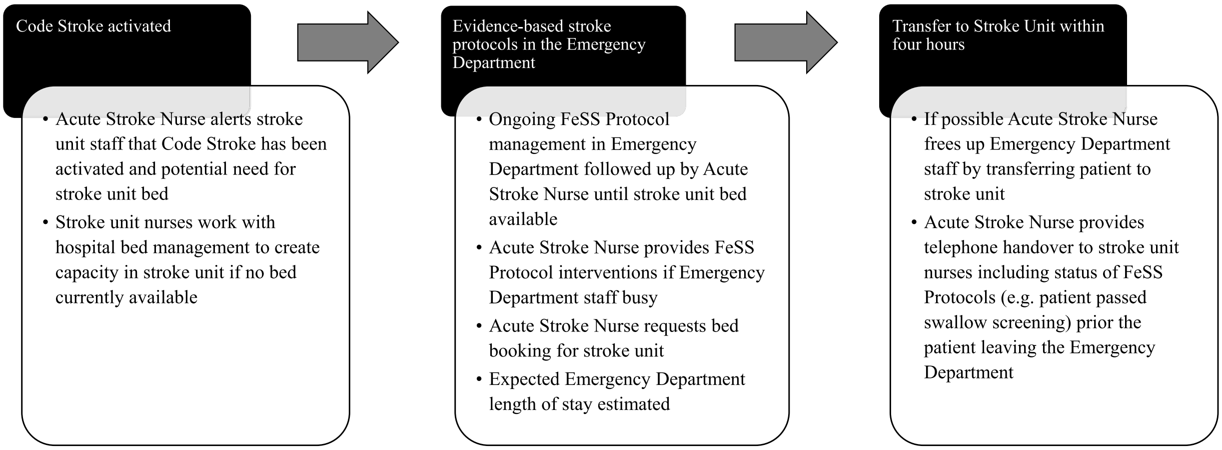

Fig. 1. Enhanced Acute Stroke Nurse role in Code Stroke 2.0.

patients, and stroke unit processes of care were compared between patients in the pre- and post-intervention cohorts using the t-test or Mann–Whitney U test for continuous variables and the Chi-square test or Fisher's exact test for binary variables.

Pre- and post-intervention outcomes were compared with a logistic regression, adjusting for patient age and sex. Adjusted difference (aDiff) and 95% confidence intervals (CI) in pre- and post-intervention proportions were calculated using the average marginal effect from the logistic model. Adjustment for stroke severity was unable to be performed due to missing data from the pre-intervention cohort.

As the expanded Acute Stroke Nurse role operated for 13 h per day on weekdays and 8 h per day on weekends, a subgroup analysis was performed to examine the effect of the intervention during business hours only (between 8:00AM and 4:30PM Monday–Friday excluding public holidays). A post hoc analysis to determine any concomitant improvement in fever, hyperglycaemia, and dysphagia management occurring on the stroke unit after the handover of the Acute Stroke Nurse to the stroke unit nurses was also conducted.

Our calculation for 2 groups of 117 patients each demonstrated 80% power to detect a difference in proportion of 0.12 from the known baseline of 0.07 for the primary outcome with an alpha of 0.05.

3. Results

3.1. Participants' characteristics

A total of 234 patients were included with 117 in the pre- and 117 in the post-intervention cohorts. Both cohorts were similar in age, gender, and stroke severity (National Institutes of Health Stroke Score). However, relative to the pre-intervention cohort, the post-intervention cohort had higher proportions of total anterior circulation and posterior circulation strokes (Oxfordshire Community Stroke Program Classification $P < 0.001$), lower levels of disability before their admission (premorbid modified Rankin Scale $P = 0.004$) and longer median time to ED arrival (185 min vs 90 min for post- and precohorts respectively, $P = 0.008$) (Table 1).

3.2. Primary and secondary outcome measures

Code Stroke activation was significantly improved in the post-intervention cohort, with 62% of patients having the Acute Stroke Nurse notified by the ED compared with just 7% (aDiff 51%, 95% CI: 45–58%) of patients before the introduction of the intervention ($P < 0.001$). Irrespective of receiving a Code Stroke or not, the intervention was also associated with a significant improvement in temperature (62% pre vs 78% post; aDiff 18%, 95% CI: 4.4–31%; $P = 0.013$) and formal blood glucose (55% pre vs 98% post; aDiff 36%, 95% CI: 25–46%; $P < 0.001$) being taken on ED arrival and a reduction in oral medications given before swallow screening (31% pre vs 14% post; aDiff −26%, 95% CI: −40% to −11%; $P = 0.00$). Thrombolysis rates were unchanged, however, the proportion of patients screened for thrombolysis eligibility improved (53% pre vs 80% post; aDiff 30%, 95% CI: 18–41%; $P < 0.001$), as did the proportion of patients transferred out of the ED to a stroke unit within 4 h of arrival (26% pre vs 41% post; aDiff 17%, 95% CI: 5.1–28%; $P = 0.014$). Overall, the intervention was associated with a significant improvement in a composite measure combining all required elements of care (Temperature on ED arrival, Finger prick blood glucose on ED arrival, Formal blood glucose on ED arrival, Given oral medications before swallow screening, Screened for thrombolysis eligibility, and Transfer to a stroke unit < 4 h from ED arrival) (5% pre vs 17% post; aDiff 12%, 95% CI: 3.8–20%; $P = 0.004$) (Table 2).

Box 2
Implementation strategy

Use of clinical champion
- An Emergency Department (ED) Staff Specialist was identified to drive clinical change in the ED working collaboratively with the Acute Stroke Nurse Clinical.

Didactic and interactive education sessions
- Two education sessions consisting of a brief PowerPoint presentation about the elements of the FeSS Protocols with an emphasis on activating calls early from triage (or prehospital where appropriate) delivered by the Acute Stroke Nurse to ED clinicians and stroke unit nurses.

Reminders
- Verbal reminders at ED medical and nursing handovers to encourage Code Stroke activations to come through to the Acute Stroke Nurse.
- Emails — reactive and proactive
- Telephone support — reactive

Performance monitoring and feedback
- Feedback of Code Stroke activation to the Head of Neurology and the Head of ED on a six-weekly basis
- Feedback of Code Stroke activation data via email newsletters to Emergency Department nursing and medical mailing lists

Table 1
Demographic characteristics of participants.

		Pre-intervention N = 117 n (%)	Post-intervention N = 117 n (%)	P value[a]
Age (years)	< 65	28 (24%)	23 (20%)	0.862
	65 to < 75	33 (28%)	33 (28%)	
	75 to < 85	35 (30%)	37 (32%)	
	85 and over	21 (18%)	24 (21%)	
Sex	Male	72 (62%)	67 (57%)	0.594
	Female	45 (38%)	50 (43%)	
OCSP	Total anterior circulation stroke (TAC)	6 (5%)	22 (19%)	< 0.001[b]
	Partial anterior circulation stroke (PAC)	63 (54%)	29 (25%)	
	Posterior circulation stroke (POC)	19 (16%)	32 (27%)	
	Lacunar stroke (LAC)	29 (25%)	27 (23%)	
	Haemorrhage	0 (0%)	6 (5%)	
	Not recorded	0 (0%)	1 (1%)	
NIHSS	0–7 (mild stoke)	91 (78%)	78 (67%)	0.345
	8–16 (moderate stroke)	19 (16%)	20 (17%)	
	17+ (severe stroke)	7 (6%)	12 (10%)	
	Not recorded	0 (0%)	7 (6%)	
Premorbid mRS[c]	0 = no symptoms at all	82 (70%)	85 (73%)	0.004[b]
	1 = no significant disability despite symptoms	7 (6%)	14 (12%)	
	2 = slight disability	21 (18%)	6 (5%)	
	3 = moderate disability	2 (2%)	9 (8%)	
	4 = moderately severe disability	3 (3%)	2 (2%)	
	5 = severe disability	1 (1%)	1 (1%)	
Onset to ED[d] (accurate) (minutes)	Median (Q1–Q3) n (pre: 51, post: 69)	90 (57–253)	185 (74–575)	0.008[e]
Onset to ED[f] (estimate) (minutes)	Median (Q1–Q3) n (pre: 95, post: 117)	220 (69–728)	513 (132–970)	0.017[e]

Missing data omitted from statistical tests.
mRS: modified Rankin Scale; NIHSS: National Institutes of Health Stroke Scale; OCSP: Oxfordshire Community Stroke Project Classification; ED: Emergency Department.
[a] Chi-squared test.
[b] Fisher exact test.
[c] Missing data pre-intervention (n = 1).
[d] Patients with accurate onset to ED arrival time only.
[e] Kruskal–Wallis rank-sum test.
[f] Patients with estimated onset to ED arrival or 'last seen well' time.

3.3. Business hours subgroup analysis

For the subgroup of patients who arrived at the ED within business hours (Table 3), there was a statistically significant improvement in the primary outcome of Code Stroke activation (10% pre vs 79% post; aDiff 46%, 95% CI: 42–51%; P < 0.001) and the secondary outcomes of formal blood glucose on arrival (57% pre vs 98% post; aDiff 35%, 95% CI: 20–51%; P < 0.001), reduction in oral medications being administered before swallow screening (24% pre vs 9% post; aDiff −29%, 95% CI: −54% to −4.4%; P = 0.034) and patients screened for thrombolysis (45% pre vs 82% post; aDiff 36%, 95% CI: 23–49%; P < 0.001). Improvement in transfer of patients to the stroke unit from the ED in less than 4 h (25% pre vs 45% post; aDiff 20%, 95% CI: 0.0–38%; P = 0.051) was marginally nonstatistically significant at the 5% level, but the number of patients in this subgroup analyses was small. Given that this was a feasibility study, statistical differences were not necessarily expected.

3.4. Post hoc analysis of subsequent Fever, Sugar and Swallow management in the stroke unit

There was an improvement in blood glucose monitoring compliance on stroke unit admission and subsequent six-hourly readings (14% pre vs 27% post; P = 0.015) and compliance with six-hourly blood glucose readings for the first 72 h in the stroke unit (16% pre vs 41% post; P < 0.001). Improved monitoring over the first 72 h was also demonstrated for four-hourly temperature readings (56% pre vs 69% post; P = 0.043) (Table 4).

Table 2
Process of care outcomes by intervention cohort.

	Pre-intervention N = 117 n (%)	Post-intervention N = 117 n (%)	Adjusted difference %, (95% CI)	P value[a]
Code Stroke activation on ED arrival	8 (7%)	72 (62%)	51 (45, 58)	< 0.001
Temperature on ED arrival	73 (62%)	91 (78%)	18 (4.4, 31)	0.013
Finger-prick blood glucose on ED arrival	35 (30%)	43 (37%)	7.6 (−5.9, 21)	0.275
Formal blood glucose on ED arrival	64 (55%)	115 (98%)	36 (25, 46)	< 0.001
Given oral medications before swallow screening	36 (31%)	16 (14%)	-26 (−40, −11)	0.001
Screened for thrombolysis eligibility	62 (53%)	94 (80%)	30 (18, 41)	< 0.001
Transfer to a stroke unit < 4 h from ED arrival	31 (26%)	49 (42%)	17 (5.1, 28)	0.014
All required elements of care[b]	6 (5.1%)	20 (17%)	12 (3.8–20)	0.004
ED arrival to stroke unit transfer time (minutes) median (Q1–Q3)	366 (255–469)	306 (180–439)	-49 (−159, 60)	0.474

ED: Emergency Department; CI: confidence intervals.
[a] Wald test on logistic regression intervention coefficient.
[b] All required elements of care include Temperature on ED arrival, Finger prick blood glucose on ED arrival, Formal blood glucose on ED arrival, Given oral medications before swallow screening, Screened for thrombolysis eligibility, and Transfer to a stroke unit < 4 h from ED arrival.

Table 3
Process of care outcomes by intervention cohort (business hours only).

	Pre-intervention (N = 51)	Post-intervention (N = 56)	Adjusted difference % (95% CI)	P value[a]
Code Stroke activation on ED arrival	5 (10%)	42 (79%)	46 (42, 51)	< 0.001
Temperature on ED arrival	35 (69%)	42 (75%)	2.0 (−18, 22)	0.551
Finger-prick blood glucose on ED arrival	15 (29%)	19 (34%)	5.1 (−15, 25)	0.624
Formal blood glucose on ED arrival	29 (57%)	55 (98%)	35 (20, 51)	< 0.001
Given oral medications before swallow screening	12 (24%)	5 (9.0%)	-29 (−54, −4.4)	0.034
Screened for thrombolysis eligibility	23 (45%)	46 (82%)	36 (23, 49)	< 0.001
Transfer to a stroke unit < 4hrs from ED arrival	13 (25%)	25 (45%)	20 (0.0, 38)	0.051
All required elements of care[b]	5 (10%)	7 (13%)	2.5 (−9.7, 15)	0.692
ED arrival to stroke unit transfer time (minutes) median (Q1–Q3)	366 (260–460)	282 (174–410)	-91 (−227,44)	0.189

ED: Emergency Department; CI: confidence intervals.
[a] Wald test on logistic regression intervention coefficient.
[b] All required elements of care include Temperature on ED arrival, Finger prick blood glucose on ED arrival, Formal blood glucose on ED arrival, Given oral medications before swallow screening, Screened for thrombolysis eligibility and Transfer to a stroke unit < 4 h from ED arrival.

Table 4
Post hoc analysis of Fever, Sugar and Swallow management in the stroke unit.

	Pre-intervention (N = 117)	Post-intervention (N = 117)	P value[a]
Fever			
Temperature reading on admission to SU	104 (89%)	95 (81%)	0.143
Four-hourly temperature readings during the first 72 h in SU	65 (56%)	81 (69%)	0.043
Temperature reading on admission to SU and four-hourly temperature readings in SU	60 (51%)	70 (60%)	0.236
Temperature ≥37.5 °C whilst in SU	8 (7%)	18 (15%)	0.061
Received paracetamol within 60 min of the first SU temperature reading ≥37.5 °C	2 (25%)	1 (6%)	0.215
All fever care elements completed	46 (39%)	56 (48%)	0.235
Sugar			
Finger-prick BGL glucose reading on admission to SU	76 (66%)	71 (61%)	0.589
Six-hourly glucose readings during the first 72 h in SU	19 (16%)	48 (41%)	< 0.001
BGL reading on admission to SU and six-hourly BGL readings in SU	16 (14%)	32 (27%)	0.015
Blood glucose reading > 10 mmol/L whilst in SU	19 (16%)	15 (13%)	0.578
Received insulin within 60 min of the first SU blood glucose reading > 10 mmol/L	1 (5%)	3 (20%)	0.299
All sugar care elements completed	10 (9%)	21 (18%)	0.054
Swallow			
Was the patient given oral food or fluids in SU before the first swallow screen/assessment?	4 (3%)	0 (0%)	0.122
Was the patient given oral medication in SU before the first swallow screen/assessment?	6 (5%)	2 (2%)	0.281
Failed the swallow screen in SU	10 (6%)	13 (11%)	0.661
After failing a swallow screen in SU, received a formal swallow assessment by speech pathologist	8 (80%)	12 (92%)	0.560
All swallowing care elements completed	109 (93%)	114 (97%)	0.217

SU: stroke unit; BGL: blood glucose level.
'On admission' defined as within 60 min of arrival to SU four hourly defined as 6 readings within each 24-h period from SU admission six hourly defined as 4 readings within each 24-h period from SU admission.
[a] P values from chi-squared test, or Fisher exact test for counts less than five.

4. Discussion

This model of care demonstrates previously unrecognised potential for improving stroke outcomes, facilitating prompt evidence-based care in the ED. We found that implementation of a model of care using an expanded Acute Stroke Nurse role to respond to Code Stroke activations within the ED significantly improved the likelihood of Code Stroke being activated by the ED, and importantly, improved use of stroke-specific evidence-based processes of care whilst reducing ED length of stay with rapid admission to the stroke unit. Delays in transfer from the ED to a stroke unit are an important predictor of in-hospital mortality and poor functional recovery at discharge in stroke patients (Busingye et al., 2018; Rincon et al., 2010). Our intervention has clearly shown improved timely access to early interventions of demonstrated effectiveness, specifically the FeSS Protocols and some improvement in stroke unit care, which are important priorities for improving stroke care outcomes. Implementing this model of care will be a worthwhile investment for health systems globally.

Prior efforts to implement the FeSS Protocols into the ED in the T[3] Trial were unsuccessful in improving stroke processes of care in EDs (Middleton et al., 2019). One of the reasons attributed to the neutral outcome of the Trial was the complexity of the ED environment, the variable ED case mix, of which stroke only makes up a small proportion and the high staff turnover (McInnes et al., 2020). Our study has shown that a model of care, which uses the Acute Stroke Nurse role to respond to Code Stroke within the ED, can help to circumvent these barriers by providing specialist stroke nursing care at the bedside, or facilitating ED nurses to do so, before the patient arrives in the stroke unit. Our results also showed continued improvements in blood glucose monitoring compliance in the stroke unit after care was handed over to the stroke unit nurses, which may suggest carryover effects of the intervention.

Commonly, in many hospitals, nurses' participation in the Code Stroke model of care is aimed at improving time to treatment for reperfusion therapies (Mainali et al., 2017). However, our study findings show that nurse participation in Code Stroke can be expanded beyond merely assisting with reperfusion therapy administration, to early implementation of crucial hyperacute therapies such as the FeSS Protocols. To our knowledge, the Code Stroke 2.0 feasibility study is one of the few studies to deliver a nursing model of care that makes use of registered nurses, specifically acute stroke nurses, as opposed to advanced- practice nurses and nurse practitioners (senior clinical nursing experts working with a high level of autonomy within their respective practice scopes) (Australian College of Nursing, 2019). Our study demonstrates that registered nurses working to the full potential of their scope of practice can improve processes of care for acute stroke patients. Further, potential cost benefits to health services may be achieved from using registered nurses to deliver the Stroke Code 2.0 intervention compared with advanced-practice nurses. The cost of employing an advanced-practice nurse is substantial with direct salary cost ranging between AU $116,000 and AU $119,600 per annum at the time of the study (Australian College of Nursing, 2019). Hence, our findings are topical and timely as the Australian nursing workforce examines future opportunities to maximise the potential of registered nurses to work to the full extent of their scope of practice (Australian College of Nursing, 2019; Duffield, Gardner, Doubrovsky, & Adams, 2021).

Our study demonstrated an improvement in the proportion of patients who were screened for thrombolysis eligibility after implementation of the intervention. However, thrombolysis treatment rates between the pre- and post-intervention groups remained the same. This is consistent with other published studies of stroke nurse-led models of care, which have demonstrated improved metrics for thrombolysis such as treatment times, with no effect on thrombolysis treatment rates (Heiberger et al., 2019; Middleton et al., 2019; Moran, Nakagawa, Asai, & Koenig, 2016). Importantly, we did not aim to improve thrombolysis treatment rates and the improvement in thrombolysis eligibility screening was likely a function of improved documentation.

We acknowledge that additional funding was required to provide the afterhours Acute Stroke Nurse coverage, however, the business hours-only subgroup analysis demonstrated that implementation of the intervention during these hours also resulted in improvements in FeSS management and thrombolysis screening. This is a noteworthy strength of our study, signifying those hospitals with business hours-only stroke nurse availability can implement this model of care and potentially attain similar results. Our study is further strengthened by the pragmatic study design with limited exclusion criteria, providing a more real-world patient population that is likely to be applicable in other hospitals. During the time of this feasibility study, other potential confounding elements of the service such as afterhours stroke registrar cover, 24/7 cover of a neurointerventionist for endovascular clot retrieval and ambulance prehospital notification systems had not yet commenced.

There are some limitations to our study. Our sample was restricted to patients from a single hospital and was not tested using a randomised controlled trial design. We used a predefined dataset obtained from the multicentre cluster randomised controlled T^3 Trial for the pre-intervention cohort rather than conducting a sample-size calculation. Any larger future trial will include a formal sample-size calculation based on the results of this study. We are unable to explain the difference in stroke onset to ED arrival time between the pre- and post-intervention cohorts, but it is not due to uncertain timing from wake up strokes (Table 1). Controlling for variables in the logistic regression that may have impacted the process of care (e.g., number of ED staff present per shift, years of experience of the ASU nurse etc.) was not possible as these variables were not collected. As patient outcome data were not collected for the post-intervention cohort, we were also unable to quantify the beneficial effect of FeSS Protocol adherence on patient outcomes. Despite improvements in the use of stroke-specific evidence-based processes of care after introduction of the intervention, 100% compliance was not reached even during business hours. Further research to explore site-specific barriers to implementing the FeSS Protocols is therefore warranted. In addition, it is likely that during the relatively long duration between the pre- and post-intervention periods, there were other changes to the processes of care in the ED, which may have influenced staff performance. However, the demonstrated feasibility of this expanded role will be crucial for informing widespread uptake and potential evaluation. We have demonstrated increased uptake of the FeSS Protocols in the ED with improvement in FeSS processes of care as a result of the intervention that potentially translates to clinically meaningful benefits for stroke patients (Middleton et al., 2017).

5. Conclusion

We undertook an evaluation of a novel model of care for expedient delivery of stroke care processes in the ED. Successful implementation of interventions in healthcare settings is complex as it involves both independent and interdependent components (Breimaier, Heckemann, Halfens, Lohrmann, 2015). Hence, it is imperative to test interventions rigorously to inform large-scale clinical trials. While further evaluation of this model of care using a multicentre randomised controlled trial design is needed, we have successfully tested its feasibility and demonstrated its potential to facilitate implementation of the evidence-based FeSS Protocols in the ED. The Code Stroke 2.0 model of care prioritises timely assessment and management of acute stroke patients in the ED with prompt transfer to stroke unit and shows great promise in improving outcomes for stroke patients.

CRediT authorship contribution statement

BJ, SD, CL, EM, OF and SM conceptualized and designed the study. BJ, CB, MJ, MD and SW undertook the medical record audit/data collection. BM and BJ carried out the data analysis. BJ, SD, EM, OF, BM, SM and CD'E interpreted the data. BJ wrote the first manuscript draft. All authors read, revised and approved the final paper.

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Ethical statement

The research study was approved by the Australian Capital Territory Health Human Research Ethics Committee (ETHLR.18.008) on 18 January 2018 and included a waiver of patient consent for use of de-identified data in medical records.

Conflict of interest

None.

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