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ORIGINAL RESEARCH

Evaluation of a team-based approach for emergency department patients with time critical intracranial conditions

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Abstract

Introduction: Many time-critical neurosurgical brain conditions do not meet traditional ED major trauma or stroke team activation criteria and thus do not benefit from the associated expedited imaging and specialist review. To address this, a "Critical Head" protocol was developed. The aim was to determine the effect of this on time to CT scan, neurosurgical intervention (if indicated) and specialist team review.

Method: Quasi-experimental study, involving retrospective analyses of data of all potential Critical Head patients presenting to Wollongong ED from 1 January 2018 to 26 May 2023, with the protocol go-live on 7 March 2023. Descriptive statistics and study outcomes were compared before and after protocol implementation. R Studio 2024 was used for analyses and alpha was set to 0.05.

Results: Two hundred and two patients were included (123 control/pre-intervention, 119 intervention). There was no significant difference in age, sex or presence of intracranial conditions between groups. Median time from triage to CT decreased in the intervention group by 15% (7 min, 47[33,95] to 40 [25,66], $P = 0.020$). There was a 33% (67 min) reduction to surgery start time in the intervention (204[621752] to 137 [108247] min, $P = 0.042$) (urgent neurosurgery). Reductions in time to specialist team reviews were observed in ICU ($n = 86$, 132[58192] to 42[6103] min, $P < 0.001$) and neurosurgery ($n = 158$, 104[69 202] to 44[16111] min, $P < 0.001$). ICU and hospital length of stay did not differ significantly, nor did Glasgow Coma Outcome Scale score at discharge.

Conclusion: The Critical Head protocol for patients with time-critical intracranial conditions reduced time to CT scan, operative intervention and specialist team review.

Key words: *clinical pathway, craniotomy, emergency, injury, neurosurgery, protocol.*

Key findings

- Many ED presentations related to head injury, despite having signs of raised ICP, do not meet traditional major trauma or stroke team activation criteria or benefit from the associated expedited imaging and specialist review.
- An early notification system reduced time to urgent neurosurgery for patients with a time-critical intracranial condition by more than an hour.

Introduction

Patients with signs and symptoms of raised intracranial pressure (ICP) require urgent assessment and timely neurosurgical intervention. The main causes of acutely raised ICP include severe traumatic brain injury (TBI), intracranial bleeding and obstructive hydrocephalus, which can lead to significant neurological disability and death if there are diagnostic delays or a failure to implement early neuroprotective measures. Early identification of these patients may expedite definitive management, potentially improving patient outcomes. The impact of a head injury may extend beyond the individual, through to family and support networks, as well as an increased load on the health system. TBIs alone are estimated to have a lifetime cost between $2.5 million and $4.8 million per individual.[1]

In Australia in 2020–2021, traumatic and acquired brain injuries resulted in 406 000 ED presentations,

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142 000 hospitalisations, and 2400 deaths.[2] Among those hospitalised for head injury, intracranial injury was the most common diagnosis (22%). Australians aged 65 years and older had higher rates of head injury hospitalisation and death. Head injuries contributed to 1 in 3 fall-related hospitalisations (33%), and more than 1 in 4 fall-related deaths (27%). The other most common mechanisms of injury were assault, road trauma, cycling and sport.[3] Among our aging population, brain injury management is complicated by pre-existing co-morbidities and increased use of anticoagulant and antiplatelet agents, leading to more significant injuries, longer hospital length of stay (LOS), and increased morbidity and mortality.[4]

Many presentations related to head injury, despite having signs of raised ICP, do not meet traditional major trauma or stroke team activation criteria or benefit from the associated expedited imaging and specialist review. In 2021–2022, only 69% of Australian ED presentations for head injuries were seen within the recommended time.[2] Time from ED presentation to CT brain scan in patients with a TBI and Glasgow Coma Score ≤ 13 is a key performance indicator for Australian trauma centres, but has increased in recent years, from 44 min to 53 min.[5] Time to CT scan is associated with time to neurosurgical intervention.[6] Temporal delays in the surgical evacuation of intracranial mass lesions secondary to TBI are known to result in increased morbidity and mortality.[6] As the diagnosis of neurosurgically significant injuries is principally based on CT imaging, time to CT represents an important rate-limiting step in the diagnosis and subsequent surgical decision-making process for patients with TBI.

One strategy to decrease these delays includes the use of trauma-team type activations within hospitals for patients presenting with critical head injuries. In the United Kingdom, a 'Code Black' team activation is used in some hospitals[7] and similar processes in the United States resulted in faster transfer of patients from the ED to CT for diagnostic imaging.[8] Improved notification, response and time-based targets are likely to improve patient outcomes and patient flow.

In our metropolitan Level 2 trauma hospital, we developed a "Critical Head" protocol in response to an adverse outcome and delays to imaging and neurosurgical intervention in a young adult. Informed by best practice recommendations, "Critical Head" intends to guide and standardise initial stabilisation in ED, facilitate rapid transport to CT and subsequent transfer to operating theatres for early definitive neurosurgical intervention if required. Patients are identified using standardised criteria to capture patients with suspected raised ICP, resulting in the activation of a "Critical Head" response team. Activation of this pathway occurred through a call to the hospital switchboard and should then have been noted in the patient's record by the treating doctor or nurse. Activation of a critical head alert results in the team (ED, neurosurgery, ICU, radiology, and theatre staff) being simultaneously notified of a patient meeting criteria *via* a paging system (similar to a stroke or trauma call), allowing rapid escalation of investigations and definitive care (Fig. 1). At the time of implementation, we were unaware of any similar process operating within Australian EDs. Extensive consultation, education, testing and modifications to paging systems occurred prior to implementation.

The aim of this current study was to determine any difference in patients meeting Critical Head criteria on time to CT and neurosurgical intervention (if indicated), as well as secondary outcomes of ED and hospital LOS. We also sought to determine if all eligible patients had a Critical Head activated.

Methods

Study design and setting

In this quasi-experimental study, we retrospectively analysed data of patients presenting to Wollongong Hospital ED who met criteria for a Critical Head activation from 1 January 2018 to 6 March 2020 (control/pre-intervention) compared to 7 March 2020 to 26 May 2023 (intervention). Wollongong Hospital is a regional trauma centre that treats approximately 74 000 ED patients and 80 major trauma patients per year. Patients were screened and identified through a data extraction from FirstNet (eMR). Patients in the post cohort were cross-checked with hospital switchboard records noting activation of a Critical Head. We also used this method to confirm our screening processes. Ethical approval was obtained from the Illawarra Shoalhaven Local Health District Low and negligible risk research review committee (reference number: LNR/2021–128).

Participants

All patient presentations to Wollongong ED were screened for eligibility (Fig. 2). Patients were included if they were allocated a triage category 1, 2 or 3, with a presenting problem that may indicate a potential neurosurgical problem (head trauma, headache and reduced level of consciousness). Patients discharged home from ED, allocated to the waiting room post triage, and/or with a documented initial GCS of >13 were excluded (noting not all patients had a GCS documented, so this and other eligibility criteria, "such as required intubation", was checked in subsequent screens). The final screen involved reviewing the free text triage of each remaining patient. The manual review of each triage was conducted two triage and resuscitation level registered nurse with experience in clinical review and data collection. Patients clearly ineligible per the triage documentation were removed, for example "*Known epilepsy, witnessed seizure, nil injury*". If it was unclear from the triage, the first medical and nursing eMR entry was reviewed for Critical Head clinical criteria (pupillary changes, GCS ≤13, intubated, Cushing's response). The nurse reviewer cohorted any records where they were unsure, and these were reviewed with two other investigators (SM, KC).

Outcomes

The primary outcomes of interest were time from ED arrival to CT scan and neurosurgical operative intervention. Other variables included time to review by anaesthetics, neurosurgery and ICU, ED LOS, hospital LOS,

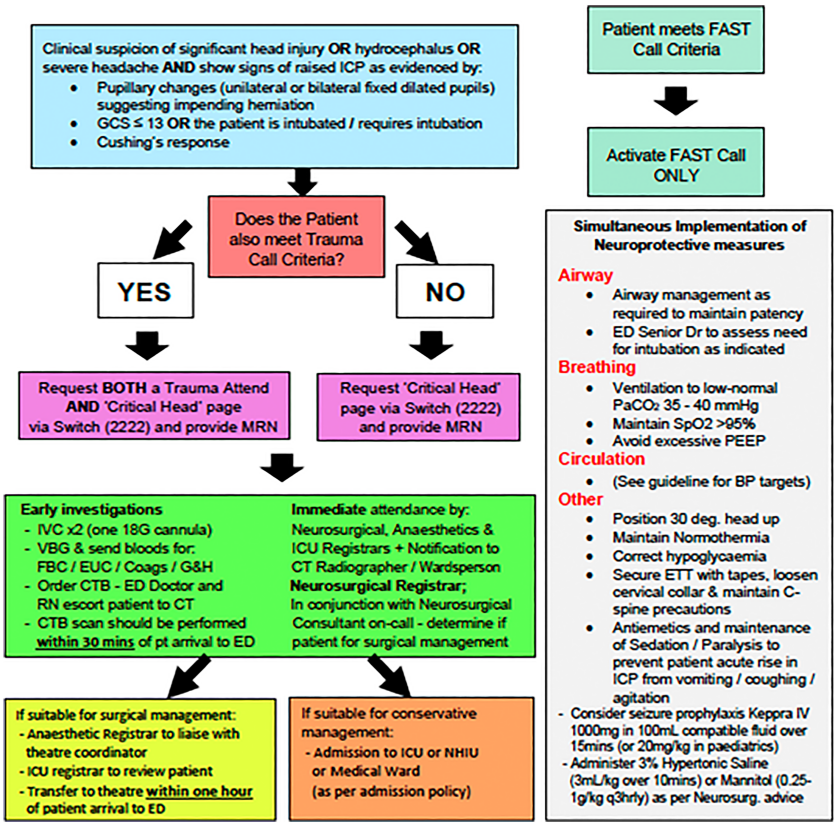

Figure 1. *Critical head protocol. BP, blood pressure; CT, computed tomography; CTB, computed tomography brain; EUC, electrolytes, urea and creatinine; FAST stroke criteria, face arms stability talking eyes; FBC, full blood count; GCS, glasgow coma scale; G&H bloods, group and hold; ICP, intracranial pressure; IVC, intravenous cannula; NHIU, neuroscience high intensity unit; PEEP, positive end-expiratory pressure; VBG, venous blood gas.*

glasgow coma outcome score at discharge, acute treatment costs and appropriate activation of Critical Head. We also included a sensitivity analysis on the indications for activation.

Data collection and analyses

Data were extracted from five sources and linked using patient name, medical record number, date of birth and date of arrival.

- FirstNet – Presenting problem, initial vital signs, patient characteristics, ED time points and free text triage.
- Admitted patient data collection – Hospital LOS, treatment costs
- PACS - Time of CT brain
- Surginet – Time to theatre, time to operative intervention.
- Manual review of the electronic medical record (FirstNet, PowerChart) – Initial nursing and medical clinical assessment, time to clinical reviews, GOS.

Data manually extracted from the electronic medical record by the registered nurses were entered into a purpose-built Redcap database hosted at the study site. Built-in validation checks, including predefined variable formats and range restrictions, were incorporated to enhance data consistency, accuracy, and minimise entry errors, such as time/date anomalies. The registered nurses completed five records together, in the same room, with in-person support from author KC to clarify any questions.

Time variables exceeding 24 h were excluded from analysis due to their misalignment with the research question. Descriptive statistics were used to summarise patient characteristics and study outcomes. Differences between categorical variables were assessed using Pearson's Chi-squared test, with *post hoc* pairwise comparisons adjusted for multiple testing when significant. If low expected cell counts were encountered, Fisher's Exact test was applied, followed by *post hoc* pairwise comparisons using Holm adjustment. For continuous or ordinal variables, the Wilcoxon rank-sum test was used to assess differences in distributions, and the Wilcoxon Rank-Sum Exact test was applied when small sample sizes resulted from missing data. Linear regression analyses were conducted on the time to CT scan and time to surgery start. Since both variables exhibited non-normal distributions, they were log-transformed for analysis. The models adjusted for confounding variables including age, sex, GCS score ≤ 13, presenting problem (e.g., falls, headache and trauma), triage category (1–4) and brain scan pathology (the latter included only in the surgery regression model). Regression coefficients and confidence intervals were back transformed to report the percentage change associated with each predictor. Logistic analyses were conducted to examine the associations between the critical head activation criteria and the likelihood of having a positive CT scan or pathology requiring surgery. The confounding variables included in this analysis were age, sex and presenting problem. The factors considered in this analysis were suspected head injury; hydrocephalus; severe headache; GCS score ≤ 13 or the need for intubation; pupillary changes; and Cushing's response. Exploratory logistic analysis was performed for various GCS cutoff scores (binary factor in each model): GCS ≤13 OR requiring intubation; GCS ≤12 OR requiring intubation; GCS ≤11 OR requiring intubation; down to GCS = 3 OR requiring intubation. For each model, the covariates included age, sex, GCS score ≤ 13, and presenting problem. All analyses were conducted using R Studio 2024, with an alpha level set at 0.05. No *a priori* sample size calculation was performed.

Results

A total of 242 participants were included in the study (123 control

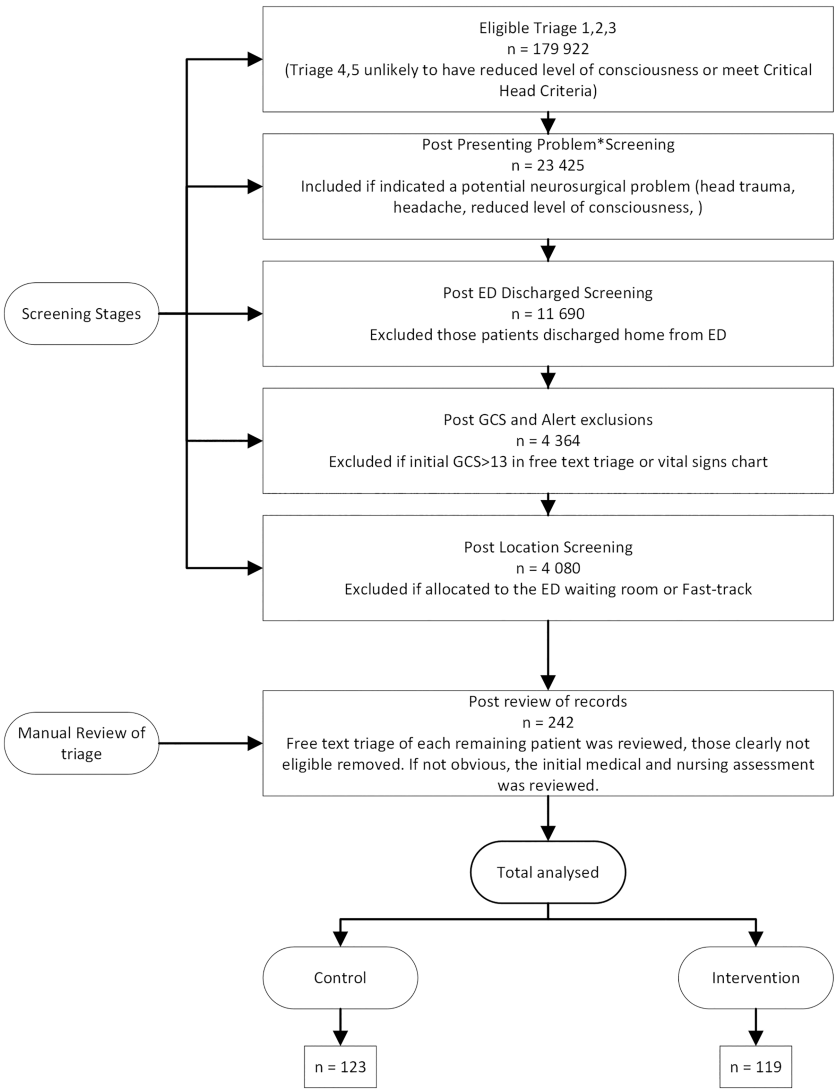

Figure 2. *CONSORT flow diagram of screening. *Altered level of consciousness (LOC); assault, alleged; Confusion; encephalopathic; Fall/Falls; head injury; headache; intoxicated; motor vehicle accident (MVA); postictal; seizure or trauma; ED; glasgow coma scale (GCS).*

group, 119 intervention group). There was no significant difference in median age or sex between groups (Table 1). Significant differences were observed between groups for presenting problem ($P = 0.019$), with *post hoc* analysis indicating altered consciousness was 21% more frequent (55% vs. 34%) in the control group (OR = 2.34; $P = 0.008$). The proportion of patients with a GCS ≤13 or intubated/requires intubation ($X^2_1 = 4.13$, $P = 0.042$) was 7% higher in the control group. GCS specifics are found in Table S1.

The median (IQR) time from triage to CT scan time decreased in the intervention group by 7 min [47(33 to 95) to 40(25 to 66) min, $P = 0.020$], equating to a 15% decrease. Of the patients who required urgent neurosurgery, there was a 33% (67 min) reduction to the surgery start time in the intervention group [204(156–1141) to 137(108 to 247) min, $P = 0.042$]. Similarly, statistically significant reductions were observed in time to specialist team reviews, in particular ICU (68.2% [132 (58 to 192) to 42 (6 to 103) min, $P < 0.001$]); and Neurosurgery review times (57.7% [104(69 to 202) to 44 (16 to 111) min, $P < 0.001$]). ICU and hospital length of stay did not change, nor did GOS at discharge (Table 2). Median (IQR) treatment costs increased from $1502 (910, 8620) to $3088 (1695, 13242), in particular allied health, radiology and pathology costs (Tables S2 and S3). Two-thirds (67%, $n = 80$) of patients in the intervention group had a positive CT finding, and of those, 34% ($n = 27$) required neurosurgical operative intervention.

Regression analysis of time to CT scan data

The regression model was statistically significant ($F\ [12,\ 223] = 7.86$, $P < 0.001$), explaining approximately 29.7% of the variance in CT scan times ($R^2 = 0.2973$). Compared to the control group, patients in the intervention group had a significantly shorter time to CT scan (Estimate = −0.231, $P = 0.017$). Triage level 3, in particular, was associated with a longer time to CT scan (Estimate = 0.937, $P < 0.001$). Detailed regression coefficients, confidence intervals and *P*-values are presented in Table S4. Residuals were approximately normally distributed, ranging from −1.61 to 3.15, with a residual standard error of 0.685. Back-transformed data are presented in Figure 3, showing the percentage change in CT scan times associated with each predictor.

Points represent the estimated percent change in the outcome, with confidence intervals indicated by the horizontal lines. Predictors are coloured by their significance: red for significant ($P < 0.05$) and blue for non-significant results. The dashed vertical line at zero represents no effect on the outcome. Predictors include age, sex, triage level, GCS ≤13 (and/or required intubation) and clinical presentation.

Regression analysis of time to surgery data

The regression model was not statistically significant ($F(15,21) = 0.96$, $P = 0.522 F(15,\ 21) = 0.96$, $P = 0.522 F(15,21) = 0.96$, $P = 0.522$), indicating that the predictors collectively did not explain a significant portion of the variance in log-transformed surgery start times. None of the individual predictors, including age, sex,

TABLE 1. *Participant characteristics*

Characteristics	Control, $n = 123$[a]	Intervention, $n = 119$[a]	Test statistic	*P*-value Test
Age (years)	72 (50, 85)	69 (44, 80)	U = 80 181	0.39[b]
Sex			$X^2_1 = 0.52$	0.82[c]
Female	53 (43%)	53 (45%)		
Male	70 (57%)	66 (55%)		
Presenting problem			**Fishers Exact**	**0.019**[d]
Altered consciousness	68 (55%)	41 (34%)	OR = 2.34	**0.008**
Fall / Falls	20 (16%)	26 (22%)		0.963
Headache	3 (2.4%)	3 (2.5%)		1.000
Other	9 (7.3%)	17 (14%)		0.488
Trauma	23 (19%)	30 (25%)		0.963
Weakness focal	0 (0%)	2 (1.7%)		0.963
Arrival mode			Fishers Exact	0.762[d]
Air service	2 (1.6%)	3 (2.5%)		
Internal transport	1 (0.8%)	0 (0%)		
Private car	4 (3.3%)	2 (1.7%)		
State ambulance vehicle	116 (94%)	114 (96%)		
Triage category			**Fishers Exact**	**0.007**[d]
1	66 (54%)	84 (71%)	**OR = 0.48**	**0.033**
2	41 (33%)	29 (24%)		0.312
3	16 (13%)	5 (4.2%)		0.063
4[e]	0 (0%)	1 (0.8%)		0.492
Suspicion of head injury	92 (75%)	87 (73%)	$X^2_1 = 0.09$	0.765[c]
Suspicion of hydrocephalus	19 (15%)	20 (17%)	$X^2_1 = 0.08$	0.773[c]
Severe headache	14 (11%)	14 (12%)	$X^2_1 = 0.01$	0.926[c]
Pupillary changes	24 (20%)	17 (14%)	$X^2_1 = 1.17$	0.279[c]
GCS < = 13 or intubated/requires intubation	118 (96%)	106 (89%)	$\mathbf{X^2_1 = 4.13}$	**0.042**[c]
Cushing's response	10 (8.1%)	5 (4.2%)	$X^2_1 = 1.61$	0.205[c]
GCS on arrival	10.0 (7.0, 12.0) 1[f]	8.0 (3.0, 12.8) 5[f]	U = 80 166.5	0.104[b]
CT Pathology categories			**Fishers Exact (sim *P*-value)**[g]	**0.007**
Positive CT	**68 (55%)**	**80 (67%)**		
Acute hydrocephalus / shunt blockage	5 (4.1%)	2 (1.7%)		
Acute Subdural/Extradural	22 (18%)	21 (18%)		
Intracerebral haemorrhage	1 (0.8%)	10 (8.4%)		
Intraventricular haemorrhage	8 (6.5%)	3 (2.5%)		
Multiple intracranial haemorrhages/contusions/oedema	27 (22%)	32 (27%)		
Subarachnoid haemorrhage	5 (4.1%)	12 (10%)		
Negative CT	**55 (45%)**	**39 (33%)**		
No acute intracranial pathology	55 (45%)	39 (33%)		
Patients that received surgery[h]	16 (13%)	27 (23%)		
Surgical categories			Fishers Exact	0.15

(*Continues*)

TABLE 1. *Continued*

Characteristics	Control, $n = 123$[a]	Intervention, $n = 119$[a]	Test statistic	*P*-value Test
Burrhole or craniotomy + evacuation of haematoma / clipping of aneurysm	12 (57%)	16 (55%)		
Revision VP shunt or insertion of EVD or ICP	4 (19%)	11 (38%)		

[a]Median (IQR). [b]Wilcoxon rank sum test. [c]Pearson's χ^2 test. [d]Fisher's exact test. [e]Excluding those receiving non-neurological surgeries. [f]Fisher's exact test for count data with simulated *P*-value (based on 2000 replicates, *n* [%]), Glasgow Coma Scale (GCS). [g]Missing data per group (GCS). [h]This patient deteriorated after triage and was identified through switchboard critical head activation records.

presenting problem, or clinical conditions (e.g., acute subdural/extradural), reached statistical significance. Residuals were approximately normally distributed, ranging from −0.68 to 1.56, with a residual standard error of 0.533.

Uptake and prediction of positive CT brain or neurosurgical intervention

In the post-intervention group, there was complete uptake of the Critical Head protocol, with activation occurring for all eligible patients. The screening process did not capture all eligible patients. A manual review of switchboard records found an additional three critical head patients in the intervention group. The median (IQR) arrival GCS of patients who had pathology on their CT brain was 8.0 (4.0, 11.0), and for those who underwent surgery, it was 10.0 (7.0, 12.0) (Table S5). Of those who had a positive CT brain and did not go for operative intervention, around half (54% control, 58% intervention) died, likely indicating their pathology was likely catastrophic and explaining the lower GCS in this group. No critical head activation criteria were statistically significant predictors of a positive CT brain or the need for surgery (Tables S6 and S7).

Discussion

The Critical Head protocol for patients with time-critical intracranial conditions reduced time to CT scan, operative intervention and specialist team review. ICU and hospital length of stay did not differ significantly, nor did the Glasgow coma outcome scale score at discharge. Although the time to CT reduced, it was only 7 min and unlikely to be a significant contributor to the large reduction in time to operative intervention. It is more likely that the significantly earlier patient review by anaesthetics and neurosurgical teams, those necessary for operative intervention to proceed, was responsible. The adoption of protocols aligned with evidence-based guidelines informed by implementation science principles has been shown to enhance the efficiency and effectiveness of the delivery of care in hospital settings, reducing time to definitive care for a variety of conditions and clinical issues.[9–14] For example, implementing a multidisciplinary protocol for TBI treatment at a children's hospital led to improved survival rates and a reduction in the duration of intracranial pressure elevation.[14]

A third (33%) of patients who received a critical head activation did not have any pathology on CT, and 77% of patients had no operative intervention. This could also be expressed as a 33% overtriage rate. Although arbitrary, in trauma, an undertriage rate of <5% and an overtriage rate of <35% for severely injured patients is considered acceptable.[15] To prevent undertriage or delays to treatment, an overtriage rate of 25%–35% is considered acceptable. Older persons are often undertriaged, and it is pleasing to note that in our study this was not demonstrated.[16] The protocol should be refined to consider staff workload, wellbeing and fatigue of neurosurgical trainees who are on call after hours in addition to their in-hours workload, who already have a 44% burnout rate.[17] There is a clear relationship between on-call shifts, poorer working memory,[18] depressive symptoms and burnout.[19]

We were unable to find any significant associations with critical head activation criteria and a positive head CT scan or requirement for neurosurgery. The median GCS for patients who underwent surgery was 8, and we will discuss the refining of our protocol to consider this finding.

A larger study could explore this further. The increase in treatment costs despite no increase in hospital or ICU LOS could be reflective of changes to recording costs.

Limitations and strengths

The retrospective study design did not enable assessment of temporal changes unrelated to the protocol change, and other analytic methods such as an interrupted time series analysis may have provided more information. It is possible that all eligible patients in the pre-group were not identified. As exemplified by the patient in the post-group who received a triage category 4, rapidly deteriorated and then needed a critical head activation. It is possible the same situation occurred in the pre-group, but we are unable to ascertain this as patients with a triage category greater than 3 were excluded. Retrospective data collected from chart review is reliant on the quality of documentation. This is known to be poor, particularly in the ED,[20] despite being a requirement of professional

TABLE 2. *Primary and secondary outcomes*

Outcome	*n*	Control, *n* = 123†	Intervention, *n* = 119†	*P*-value test
Time to (min)				
CT Request	242	15 (10, 35)	15 (8, 33)	0.4‡
CT Scan	242	47 (34, 96)	40 (25, 66)	**0.020**‡
CT Report Verified	242	136 (92, 255)	136 (93, 221)	0.9‡
Surgery Scheduled	43	137 (62, 1017)	113 (26, 203)	0.5§
		107¶	92¶	
Surgery Check in	43	812 (746, 1752)	757 (715, 818)	0.075‡
		107¶	92¶	
Surgery Start	43	204 (156, 1141)	137 (108, 247)	**0.042**‡
		107¶	92¶	
Anaesthetic Review	38	45 (0, 143)	5 (0, 26)	0.4‡
		115¶	89¶	
ICU Review	86	132 (58, 192)	42 (6, 103)	**<0.001**‡
		88¶	68¶	
Neurosurgery Review	158	104 (69, 202)	44 (16, 111)	**<0.001**‡
		53¶	31¶	
Length of stay (LOS)				
Hospital LOS (Days)	238	2 (0, 8)	3 (1, 12)	0.2‡
		1¶	3¶	
ED LOS (Min)	239	268 (167, 479)	273 (169, 622)	>0.9‡
			3¶	
ICU LOS (Days)	75	1.9 (1.5, 4.6)	2.1 (0.7, 4.2)	0.3§
		93¶	74¶	
Glascow outcome at discharge (GOS)	242			0.2††
Died (1)		44 (36%)	49 (41%)	
Persistent vegetative (2)		0	0	
Severely disabled (disabled and dependent) (3)		5 (4.1%)	9 (7.6%)	
Moderately disabled (disabled but independent) (4)		10 (8.1%)	16 (13%)	
Good recovery (5)		49 (40%)	33 (28%)	
Unknown		15 (12%)	12 (10%)	
Costs (ED and acute combined)				
Total costs		$9432 ($2209 – $22062)	$12 840 ($5596 –$34 509)	**0.007**§
Patients with a positive CT		$11 936 ($3288 – $23011)	$13 423 ($6748 –$42 299)	**0.049**‡
Patients receiving surgery		$26 617 ($21 062 – $65116)	$49 088 ($13 201 –$90 444)	0.5‡

†Median (IQR); *n* (%). ‡Wilcoxon rank sum test. §Wilcoxon rank sum exact test. ¶Missing data per group for specific variable. ††Pearson's χ^2 test. CT, computed tomography; GOS, glasgow outcome scale; LOS, length of stay.

responsibility.[21] Further, time-point data relied on the time that the clinician wrote their documentation, or the time the nurse noted their arrival to the ED. We did not collect data on treatments recommended as part of the protocol, such as neuroprotective measurements and targeted outcomes including blood pressure and end-tidal CO2, or their effect, if any, on patient outcomes. We are unable to explain the increases in pathology and

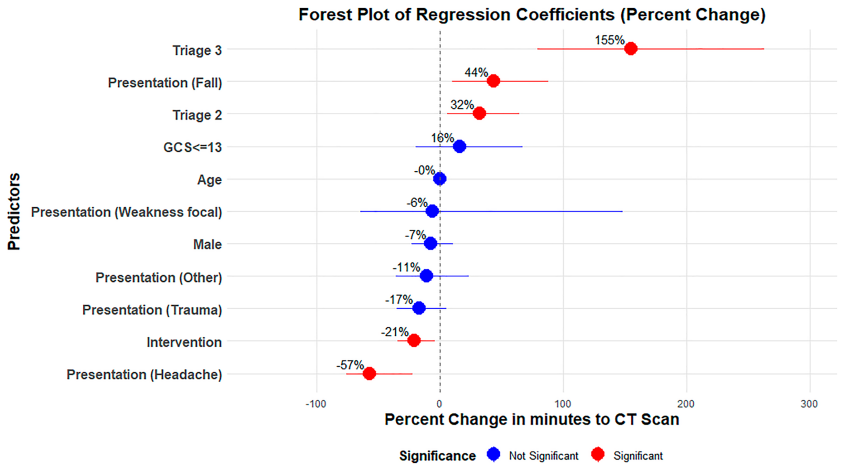

Figure 3. *Forest plot of percentage change in minutes to CT scan for various predictors in the regression analysis.*

radiology costs. They may be attributable to more judicious documentation of costs or a change in finance systems. As highlighted by the patient in the post-group who received a triage category 4, and then deteriorated and had a critical head activation from the resuscitation bay. It is possible the same type of situation occurred in the pre-group, but we are unable to ascertain this. This was a small, single-centre study, and application of this protocol would be limited in hospitals where all or some of the above resources are not directly accessible or accessible in a timely fashion. Consideration of a matrix-wide approach for peripheral sites is warranted. We did include this in our protocol; however, we were unable to measure success.

Conclusion

The introduction of a critical head protocol for patients with time-critical intracranial conditions resulted in reduced time to CT scan, operative intervention and specialist team review.

Acknowledgement

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Ethics approval and consent to participate

Ethical approval was obtained from the Illawarra Shoalhaven Local Health District Low and Negligible Risk Research Review Committee (reference number: LNR/2021–128).

Competing interests

None declared.

Data availability statement

The original datasets generated and analytic data sets for this study are not publicly available because of HREC requirements. De-identified and aggregated data sets may be available on application to the corresponding author and subject to the HREC approval.

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