Trauma Team Activation: improved care of major trauma patients

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ABSTRACT

AIM: To assess whether Trauma Team Activation (TTA) at Christchurch Hospital is associated with reduced mortality or improves in-hospital care for major trauma patients, and review differences in the two-tier activation system (Trauma Call versus Trauma Standby).

METHODS: A retrospective observational study of major trauma patients presenting to Christchurch Emergency Department (ED) 2018–2019. Univariate analyses were undertaken followed by multivariate analyses controlling for age and injury severity score (ISS).

RESULTS: Major trauma patients with a TTA had a higher mean ISS ($p<0.001$) compared to patients without TTA. After controlling for age and ISS, TTA was associated with decreased time to CT ($p<0.001$), and shorter ED length of stay (LOS) ($p<0.001$). Despite an increased rate of surgery (OR 1.9, 95%CI:1.2–3.0) and admission to ICU (OR 4.1, 95%CI:2.0–8.5), with longer total hospital LOS ($p<0.001$). When compared to those with a Trauma Standby, patients with a full Trauma Call had a higher mortality (OR 1.5, 95%CI:0.3–8.4), increased rates of surgery (OR 2.7, 95%CI:1.4–5.2) and ICU admission (OR 17.9, 95%CI:4.2–77.4), with a longer hospital LOS ($p=0.006$).

CONCLUSION: TTA was associated with decreased time to diagnostic imaging and definitive management in major trauma patients. Whilst causation cannot be inferred, these trends were apparent after controlling for age and ISS.

Injury is the leading cause of death for New Zealanders under the age of 35 and is the second leading cause of hospitalisation.[1] The World Health Organization (WHO) estimates that injury accounts for approximately 12% of all disability-adjusted life years (DALYs) lost.[2] Major trauma is defined in New Zealand by the New Zealand Major Trauma Registry (NZ-MTR) as Injury Severity Score (ISS) greater than or equal to 13, or death following trauma that is principally due to the injuries sustained.[3–5]

A key component of trauma systems globally is a multi-professional trauma team response.[5–7] The multi-professional team consists of specialised healthcare professionals from a variety of health backgrounds across a range of specialties including, but not limited to, emergency medicine, anaesthesia and surgical specialities.[5,8] There is strong evidence that trauma patients benefit from dedicated trauma team care.[9–12]

Christchurch Hospital uses a two-tier system for Trauma Team Activation (TTA). TTA is based on defined criteria which include both physiological and mechanism of injury parameters, and can be activated prior to, or on arrival to hospital.[6,8] For the most serious traumas a “Trauma Call” is placed via the operator, with an automated process that directs health professionals from emergency medicine, the intensive care unit (ICU), general surgery, and anaesthesia to attend in person. The radiology department and blood bank are notified.

For trauma that is predicted to be less serious based on mechanism and observations a “Trauma Standby” can be activated. This is considered the second tier of our Trauma Team Activation system. The details for this process are displayed in Appendix 1. A Trauma Standby requires that a general surgery registrar attends within 30 minutes, with radiology and blood bank also notified. This TTA system provides a pragmatic solution to limited resources, with the aim of reserving the full Trauma Call for those trauma patients predicted to be most seriously injured. The timeframe for our data collection was prior to the introduction of Code Crimson at Christchurch Hospital, which will be considered the first level of a three tier Trauma Team Activation system.

Multiple studies have shown that TTA reduces time to radiological investigation, such as computed tomography (CT), and to surgery, in addition to reducing the time taken for resuscitation.[5,10] However, there is conflicting evidence in the literature as to whether TTA reduces mortality for major trauma patients.[10,13,14] The aim of this study was to assess whether TTA in Christchurch is associated with reduced mortality for major trauma patients, and whether the two-tier system for TTA had any differences in patient outcomes for those patients who received a full Trauma Call when compared to a Trauma Standby.

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Method

The STROBE guidelines for reporting observational studies were adhered to.[15]

Study design and setting

This was a retrospective observational study conducted using data collected from major trauma patients presenting to the Emergency Department (ED) at Christchurch Hospital from 1 June 2018 to 31 May 2019. Approval for the study was granted by the University of Otago Ethics Committee (HD21/002) and the Canterbury District Health Board (RO #20227).

Setting

Christchurch Hospital is a tertiary level hospital in Canterbury, New Zealand, which covers a population of approximately 550,000.[16] It is the sole major acute referral centre in the region, with over 100,000 presentations each year, of which 400–450 are major trauma. Major spinal trauma from the lower third of the North Island and all of the South Island, and major burns from the lower three quarters of the South Island are directly transported to Christchurch Hospital.

Participants

Patients with major trauma (ISS ≥13, or death due to trauma) recorded in the Canterbury District Health Board (CDHB) Major Trauma database between 1 June 2018 and 31 May 2019 were considered eligible to be included in the study. Exclusions were made in line with the National Trauma Network, including such conditions as presentations delayed more than seven days after injury or isolated neck of femur fractures.[17] Data were extracted from the CDHB Data Warehouse, with clinical records reviewed manually for missing variables. Inter-hospital transfers, patients from the 15 March 2020 terror attack, duplicates, and patients with missing data after manual searches were excluded.

Variables

The primary outcome was to observe for differences in the in-hospital all-cause mortality for those patients who had a TTA versus vs those who did not have a TTA. Other key performance indicators (KPIs) reviewed were time to CT, ED length of stay (LOS), ICU LOS, total hospital LOS, need for surgical intervention and time to surgical intervention (in the operating theatre or interventional radiology). Categories for time to surgery were defined according to the data dictionary definition from the Major Trauma Registry.

Study size

Original study size was determined by the number of patients identified in the CDHB Major Trauma database who attended Christchurch Hospital ED in the one-year period.

Statistical methods

Statistical Packages for Social Sciences versions 26–28 (SPSS) was used for calculations.[18] TTA patients were compared to no TTA patients in terms of baseline characteristics and KPIs (primary analysis). Trauma Calls vs Trauma Standby were also compared (subgroup analysis). Supplementary analysis was also conducted for TTA vs those who did not have a TTA but met TTA criteria (supplementary analysis). Univariate comparisons were performed using Chi-squared tests for independence, odds ratios (ORs), and t-tests for independent means. Multivariate models controlling for ISS and age were also adopted for predicting the associations between TTA and Trauma Call statuses, in analyses one and two respectively, and KPIs. For the multivariate models binary logistic and cox regression models were used where most appropriate.

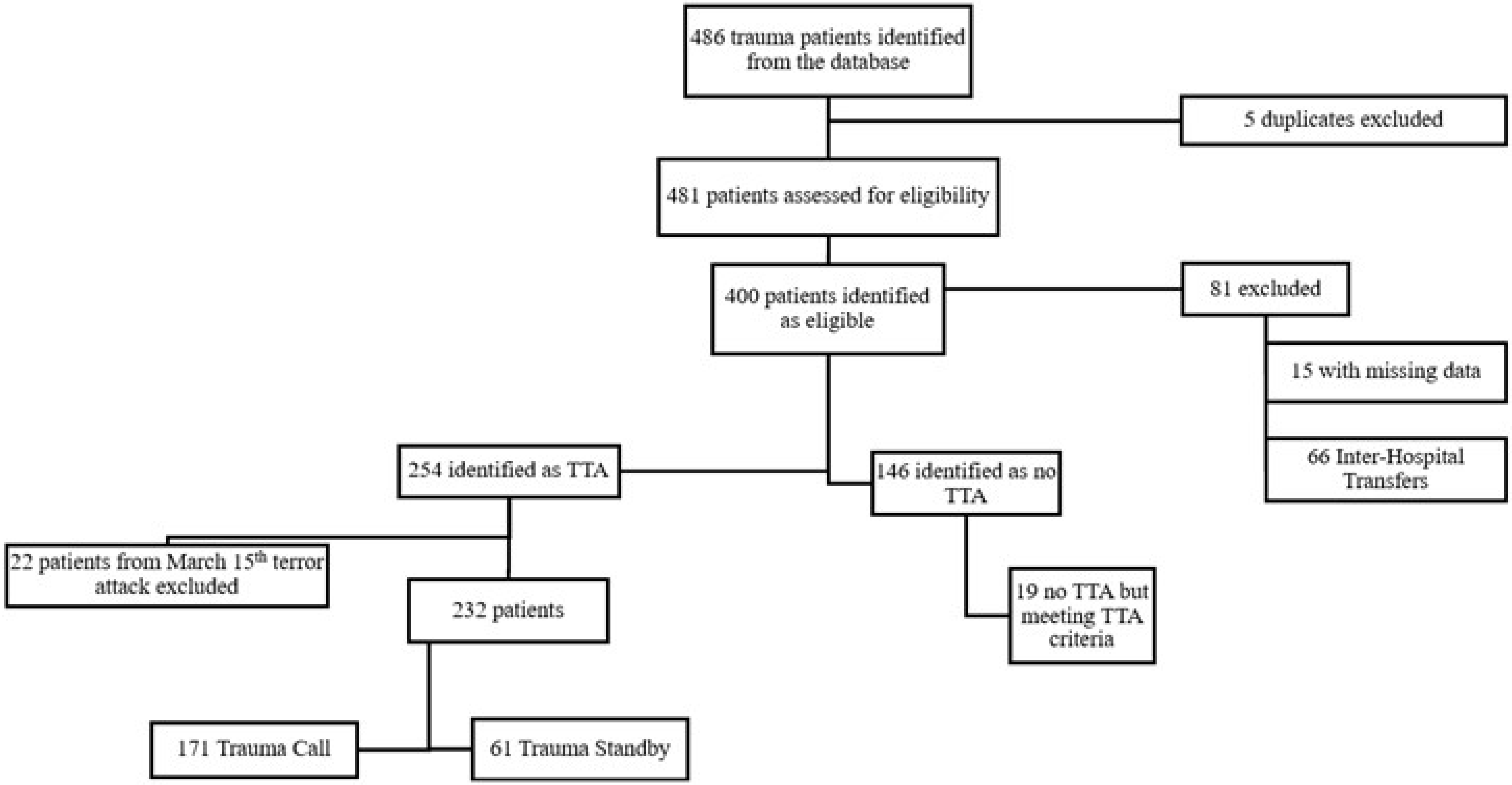
For the supplementary analyses carried out (Appendix 2) on trauma calls versus those who met criteria but were not called, the continuous variables had n<30 in the "met criteria" group and so were assessed for normality. These were found to not be normal and so non-parametric tests were used for the univariate analyses.

Results

Participants

Four hundred and eighty-one patients with major trauma attended Christchurch Hospital ED in the one-year period. After excluding inter-hospital transfers, duplicates and patients with missing data, 400 patients were eligible for inclusion in the study. There were 254 patients in this cohort who had a TTA, and 146 who did not have a TTA. Of those who had a TTA, 22 patients from the 15 March 2020 terror attack were excluded. Of the remaining 232 TTA patients, 171 received a full Trauma Call, while 61 had a Trauma Standby. Of the 146 patients who did not have a TTA, 19 of those met criteria for a TTA (see Figure 1).

Figure 1: Patient selection flow diagram.



Primary analysis: Trauma Team Activation vs those without Trauma Team Activation

Patients younger than 65 years were more likely to receive a TTA than not receive a TTA, with 0–17-year-olds being most likely to receive a TTA (OR 9.47; 95%CI:3.02–29.67). There were no gender differences in TTA rates (OR 0.76; 95%CI:0.49–1.18), nor any difference in TTA rates between different ethnicities.

Mean ISS was higher in TTA patients (21.1 [SD=8.7] vs 17.8 [SD=6.3]; p<0.001). Mechanism of injury differed (p<0.001), with patients involved in a road traffic crash (RTC) more likely to have a TTA and those with a fall less likely. Patients who had a TTA were triaged to be seen more rapidly (p<0.001). The rates of TTA varied between morning, evening, and night shifts (p=0.001) (see Table 1).

KPIs varied between patients with a TTA vs those with no TTA. Mortality rate was lower (OR 0.5; 95%CI:0.2–0.9), mean time to CT shorter (mins) (86.6 [SD=97.3] vs 228.2 [SD=218.1]; p<0.001), and ED LOS (hours) shorter for TTAs (3.8 [SD=2.8] vs 6.2 [SD=3.2]; p<0.001). Patients with a TTA had a longer mean hospital LOS (days) than no TTA (12.8 [SD=12.6] vs 5.8 [SD=4.4]; p<0.001).

Those with a TTA were more likely to be admitted to ICU compared to no TTA (OR 6.8; 95%CI:3.5–13.4). Those with a TTA were also more likely to have a longer ICU LOS (days) (11.1 [SD=12.7] vs 3.4 [SD=2.5]; p<0.001) and were more likely to require surgery (OR 2.8; 95%CI:1.8–4.3). Those patients with a TTA were more likely to require surgery in less than 24 hours. The admitting specialty varied for those with a TTA and no TTA (p<0.001), with more patients with no TTA being admitted to a non-surgical specialty.

Multivariate analysis was conducted controlling for age and ISS. The trend towards TTA being associated with lower mortality was maintained in multivariate analysis, albeit insignificantly; this change from significance to non-significance is more likely due to a change in statistical power brought about by multivariate analysis (OR 0.53; 95%CI:0.2–1.3). Multivariate analysis demonstrated that patients with a TTA had a shorter time to CT, shorter ED LOS but longer total hospital LOS (p<0.001). Patients with a TTA remained more likely to be admitted to ICU (OR 4.1; 95%CI:2.0–8.5) and have a longer ICU LOS (p=0.007), and more likely to require surgery (OR 1.9; 95%CI:1.2–3.0) (see Table 2).

Subgroup analysis: Full Trauma Call vs Trauma Standby

Mean ISS was higher in Trauma Call patients compared to Trauma Standby patients (22.7 [SD=9.3] vs 17.2 [SD=5.2]; p<0.001). Patients aged 0–17 (OR 7.14 (95%CI:1.45–35.29) and 18–29 (OR 4.13, 95%CI:1.57–10.88) were more likely than those over age 64 to have a full Trauma Call. There was no difference between males and females (OR 1.20; 95%CI:0.62–2.31), or between different ethnic groups. Mechanism of injury did not differ significantly (p=0.67) (see Table 3).

There was no significant difference in mortality between patients who received a Trauma Call vs those who received a Trauma Standby (OR 2.8; 95%CI:0.63–12.78). The mean time to CT (mins) was similar (83.3 [SD=108.7] vs 95.7 [SD=55.8]; p=0.40), although the medians differed such that Trauma Calls waited less time than Trauma Standbys (54.5 vs 84.0 mins; p<0.001), with a strong positive skew for those with a Trauma Call causing the means to be the same.

Those with a Trauma Call had a longer mean hospital LOS (days) compared to those with a Trauma Standby (14.4 [SD=13.4] vs 8.5 [SD=8.5]; p<0.001). Trauma Call patients had a shorter ED LOS (hours) (3.2 [SD=2.9] vs 5.3 [SD=1.8]; p<0.001). They were also more likely to be admitted to ICU (OR 26.6; 95%CI:6.3–112.2), more likely to require surgery (OR 3.5; 95%CI:1.9–6.5) and had a shorter time to surgery (p<0.001).

Multivariate analyses were conducted controlling for age and ISS for patients who received a Trauma Call vs Trauma Standby. Once controlled for age and ISS, mortality for Trauma Call patients became slightly higher than for Trauma Standby patients (OR 1.5; 95%CI:0.29–8.4). Mean time to CT was no different (p=0.54) between Trauma Calls and Trauma Standbys, with no difference in mean ED LOS (p=0.16). Mean hospital LOS remained significantly longer for Trauma Calls (p=0.006). The odds ratio for admission to ICU for patients with a Trauma Call fell to 17.9 (95%CI:4.2–77.4). Patients with a Trauma Call were more likely to require surgery (OR 2.7; 95%CI:1.4–5.2), albeit less so that in the univariate analysis (see Table 4).

Supplementary analysis: Trauma Team Activation vs those without a TTA but meeting TTA criteria

Clinical records were reviewed to determine whether those patients who did not have a TTA met the Christchurch Hospital Trauma Team Activation criteria. This group was compared to those patients who did have a TTA. Mean ISS was not significantly higher in TTA patients (21.1 [SD=8.7] vs 18.1 [SD=4.9]; p=0.169). There was no significant difference in mortality (OR 0.67; 95%CI:0.14–3.15) between these groups, even once ISS was controlled for (OR 0.43; 95%CI:0.07–2.73). Time to CT (mins) was shorter (86.6 [SD=97.3] vs 162.1 [SD=144.7]; p<0.001) but hospital LOS (days) was longer for patients with

Table 1: Characteristics of patients with Trauma Team Activation vs those without Trauma Team Activation

Variable	**Trauma Team Activation Mean [SD] or n (%) (n=232)**	**No Trauma Team Activation (n=146)**	**Statistical test**	**Result†**
Age				
0–17	22 (9.5%)	4 (2.7%)	Odds ratio (65+ Ref)	OR 9.47 (95% CI:3.02–29.67)
18–29	61 (26.3%)	19 (13.0%)		OR 5.53 (95% CI: 2.86–10.68)
30–49	63 (27.2%)	23 (15.8%)		OR 4.72 (95% CI: 2.51–8.86)
50–64	50 (21.6%)	38 (26.0%)		OR 2.27 (95% CI: 1.26–4.08)
65+	36 (15.5%)	62 (42.5%)		OR 1
Female	67 (28.9%)	51 (34.9%)	Odds ratio	OR 0.76 (95% CI: 0.49–1.18)
Ethnicity				
NZ European	178 (76.7%)	123 (84.2%)	Odds ratio (European Ref)	OR 1
NZ Māori	26 (11.2%)	13 (8.9%)		OR 1.38 (95% CI: 0.68–2.80)
Pasifika peoples	10 (4.3%)	2 (1.4%)		OR 3.46 (95% CI: 0.74–16.04)
Asian & Middle Eastern	15 (6.5%)	8 (5.5%)		OR 1.30 (95% CI: 0.53–3.15)
Other/ unknown	3 (1.3%)	0 (0%)		Uncalculatable
ISS‡	21.1 [10.4]	17.8 [6.3]	t-test for independent means	p<0.001
Mechanism of injury				
Road traffic crash	78 (33.6%)	11 (7.5%)	Chi-squared test for independence	p<0.001
Inflicted§	19 (8.2%)	10 (6.8%)		
Motorbike crash	24 (10.3%)	14 (9.6%)		
Fall	39 (16.8%)	71 (48.6%)		
Sport	38 (16.4%)	35 (24.0%)		
Pedestrian	19 (8.2%)	1 (0.7%)		
Other¶	15 (6.5%)	4 (2.7%)		

Table 1 (continued): Characteristics of patients with Trauma Team Activation vs those without Trauma Team Activation

Variable	Trauma Team Activation Mean [SD] or n (%) (n=232)	No Trauma Team Activation (n=146)	Statistical test	Result†
Triage on arrivalþ				
1	114 (52.1%)	6 (4.1%)	Chi-squared test for independence	p<0.001
2	100 (40.1%)	37 (25.3%)		
3	16 (7.1%)	91 (62.3%)		
4	1 (0.4%)	11 (7.5%)		
Unknown	1 (0.4%)	1 (0.7%)		
Shift of presentationµ				
AM	83 (35.8%)	54 (37.0%)	Chi-squared test for independence	p=0.001
PM	94 (40.5%)	78 (53.4%)		
NOCTE	54 (23.3%)	13 (8.9%)		
Unknown	1 (0.4%)	1 (0.7%)		

† p-values reported except in cases of odds ratios where 95% confidence intervals are reported;
‡ Injury Severity Scores available for 225 TTA and 146 no TTA;
§ Inflicted included assault, struck and gunshot;
¶ Other included crush, burns, electrocution, explosion, ingestion, jump, self-harm and unknown;
þ Triage as per Australasian Triage Scale;
µ AM=0800–1559, PM=1600–2359, NOCTE=0000–0759

Table 2: Key performance indicators for patients with Trauma Team Activation vs those without Trauma Team Activation.

Variable	Trauma Team Activation Mean [SD] or n (%) (n=232)	No Trauma Team Activation (n=146)	Univariate Statistical test	Univariate Result†	Multivariate Statistical test	Multivariate model controlling for age and ISS
Mortality	17 (7.3%)	22 (15.1%)	Odds Ratio	OR 0.5 (95% CI: 0.2–0.9)	Binary logistic	OR 0.53 (95% CI: 0.2–1.3)
Time to CT (mins)	86.6 [97.3]	228.2 [218.1]	t-test for independent means	p<0.001	Cox regression	p<0.001‡
	Median=60	Median=170	Mann–Whitney U test	p<0.001		
ED LOS§ (hours)	3.8 [2.8]	6.2 [3.2]	t-test for independent means	p<0.001	Cox regression	p<0.001‡
Admission to ICU	83 (35.8%)	11 (7.5%)	Odds Ratio	OR 6.8 (95% CI: 3.5–13.4)	Binary logistic	OR 4.1 (95% CI: 2.0–8.5)
ICU LOS§ (days)	11.1 [12.7]	3.4 [2.5]	t-test for independent means	p<0.001	Cox regression	p=0.007‡,¶
Hospital LOS§ (days)	12.8 [12.6]	5.8 [4.4]	t-test for independent means	p<0.001	Cox regression	p<0.001‡
Surgery	163 (61.0%)	57 (35.6%)	Odds Ratio	OR 2.83 (95% CI: 1.89–4.25)	Binary logistic	OR 1.9 (95% CI: 1.2–3.0)
Time to surgeryþ						
<24hrs	90 (55.2%)	17 (29.8%)	Chi-squared test for independence	p=0.02	NA	NA
24–48hrs	32 (19.6%)	14 (24.6%)				
48–72hrs	12 (7.4%)	9 (15.8%)				
>72hrs	29 (17.8%)	17 (29.8%)				
Admitting specialty						
Cardiothoracic Surgery	37 (15.7%)	28 (19.2%)	Chi-squared test for independence	p<0.001	NA	NA
General Medicine	1 (0.4%)	25 (17.1%)				
General Surgery	50 (22.1%)	27 (18.5%)				
Neurosurgery	38 (14.6%)	25 (17.1%)				

Table 2 (continued): Key performance indicators for patients with Trauma Team Activation vs those without Trauma Team Activation.

Variable	Trauma Team Activation Mean [SD] or n (%) (n=232)	No Trauma Team Activation (n=146)	Univariate Statistical test	Univariate Result†	Multivariate Statistical test	Multivariate model controlling for age and ISS
Admitting specialty						
Orthopaedic Surgery	71 (29.6%)	29 (19.9%)				
Orthopaedics –Spinal	22 (10.5%)	6 (4.1%)				
Paediatric Surgery	6 (3.7%)	0 (0%)				
Otherµ	7 (3.4%)	6 (4.1%)				

† p-values reported except in cases of odds ratios where 95% confidence intervals are reported;
‡ Cox regression for continuous variables;
§ LOS = Length of Stay;
¶ Hazard ratio increased from 0.34 to 0.39 suggests the difference between TTA and no TTA is smaller once controlled for age and ISS (both continuous);
þ % of those that had surgery,
µ Other admitting specialities = ENT, Vascular, Maxillofacial, Plastics, Urology and unknown

Table 3: Characteristics of patients with Trauma Call vs Trauma Standby.

Variable	Trauma Call Mean [SD] or n (%) (n=171)	Trauma Standby (n=61)	Statistical test	Result†
Age				
0–17	20 (11.7%)	2 (3.3%)	Odds ratio (65+ Ref)	OR 7.14 (95% CI: 1.45–35.29)
18–29	52 (30.4%)	9 (14.8%)		OR 4.13 (95% CI: 1.57–10.88)
30–49	42 (24.6%)	21 (34.4%)		OR 1.43 (95% CI: 0.61–3.32)
50–64	36 (21.1%)	14 (23.0%)		OR 1.84 (95% CI: 0.74–4.54)
65+	21 (12.3%)	15 (24.6%)		OR 1
Female	51 (29.8%)	16 (26.2%)	Odds ratio	OR 1.20 (95% CI: 0.62–2.31)
Ethnicity				
NZ European	128 (74.9%)	50 (82.0%)	Odds ratio (European Ref)	OR 1
NZ Māori	21 (12.3%)	5 (8%)		OR 1.64 (95% CI: 0.59–4.59)
Pasifika peoples	9 (5.3%)	1 (1.6%)		OR 3.52 (95% CI: 0.43–28.47)
Asian & Middle Eastern	12 (7.0%)	3 (4.9%)		OR 1.56 (95% CI: 0.42–5.77)
Other & unknown	1 (0.6%)	2 (3.3%)		OR 0.20 (95% CI: 0.02–2.20)
ISS‡	22.7 [9.3]	17.2 [5.2]	t-test for independent means	p<0.001
Mechanism of injury				
Road traffic crash	60 (35.1%)	18 (29.5%)	Chi-squared test for independence	p=0.67
Inflicted§	14 (8.2%)	5 (8.2%)		
Motorbike crash	18 (10.5%)	6 (9.8%)		
Fall	26 (15.2%)	13 (21.3%)		
Sport	25 (14.6%)	13 (21.3%)		
Pedestrian	16 (9.4%)	3 (4.9%)		
Other¶	12 (7.0%)	3 (4.9%)		

Table 3 (continued): Characteristics of patients with Trauma Call vs Trauma Standby.

Variable	Trauma Call Mean [SD] or n (%) (n=171)	Trauma Standby (n=61)	Statistical test	Result†
Triage on arrivalþ				
1	108 (63.2%)	6 (9.8%)	Chi-squared test for independence	p<0.001
2	56 (32.7%)	44 (72.1%)		
3	5 (2.9%)	11 (18.0%)		
4	1 (0.6%)	0 (0%)		
4	1 (0.6%)	0 (0%)		
Shift of presentationµ				
AM	61 (35.7%)	22 (36.1%)	Chi-squared test for independence	p=0.261
PM	65 (38.0%)	29 (47.5%)		
NOCTE	44 (25.7%)	10 (16.4%)		
Unknown	1 (0.6%)	0 (0%)		

† p-values reported except in cases of odds ratios where 95% confidence intervals are reported;
‡ Injury severity scores available for 164 Trauma Calls and 61 Trauma Standby;
§ Inflicted included assault, struck and gunshot;
¶ Other included crush, burns, electrocution, explosion, ingestion, jump, self-harm and unknown;
þ Triage as per Australasian Triage Scale;
µ AM=0800–1559, PM=1600–2359, NOCTE=0000–0759

Table 4: Key performance indicators for patients with Trauma Call vs Trauma Standby.

Variable	Trauma Call Mean [SD] or n (%) (n=171)	Trauma Standby (n=61)	Univariate statistical test	Univariate result†	Multivariate statistical test	Multivariate model controlling for age and ISS
Mortality	**15 (8.8%)**	**2 (3.3%)**	**Odds Ratio**	**OR 2.8 (95% CI: 0.63–12.78)**	**Logistic regression**	**OR 1.5 (95% CI: 0.29–8.4)**
Time to CT (mins)	83.3 [108.7]	95.7 [55.8]	t-test for independent means	p=0.40	Cox regression	p=0.54‡
	Median=54.5	Median=84	Mann–Whitney U test	p < 0.001		
ED LOS§ (hours)	3.2 [2.9]	5.3 [1.8]	t-test for independent means	p < 0.001	Cox regression	p=0.16‡
Admission to ICU	81 (47.4%)	2 (3.3%)	Odds Ratio	OR 26.6 (95% CI: 6.3–112.2)	Logistic regression	OR 17.9 (95% CI: 4.2–77.4)
ICU LOS§ (days)	11.1 [12.8]	12.5 [12.0]	t-test for independent means	p=0.89	Cox regression	p=0.96‡
Hospital LOS§ (days)	14.4 [13.4]	8.5 [8.5]	t-test for independent means	p<0.001	Cox regression	p=0.006‡
Surgery	114 (66.7%)	22 (36.1%)	Odds Ratio	OR 3.5 (95% CI: 1.9–6.5)	Logistic regression	OR 2.7 (95% CI: 1.4–5.2)
Time to surgery¶						
<24hrs	69 (60.5%)	4 (18.2%)	Chi-squared test for independence	p<0.001	NA	NA
24–48hrs	21 (18.4%)	3 (13.6%)				
48–72hrs	5 (4.4%)	6 (27.3%)				
>72hrs	19 (16.7%)	9 (40.9%)				
Admitting specialty						
Cardiothoracic Surgery	25 (14.6%)	12 (19.7%)	Chi-squared test for	p=0.07	NA	NA
General Medicine	0 (0%)	1 (1.6%)	independence			

Table 4 (continued): Key performance indicators for patients with Trauma Call vs Trauma Standby.

Variable	Trauma Call Mean [SD] or n (%) (n=171)	Trauma Standby (n=61)	Univariate statistical test	Univariate result†	Multivariate statistical test	Multivariate model controlling for age and ISS
Mortality	**15 (8.8%)**	**2 (3.3%)**	**Odds Ratio**	**OR 2.8 (95% CI: 0.63–12.78)**	**Logistic regression**	**OR 1.5 (95% CI: 0.29–8.4)**
Admitting specialty						
General Surgery	37 (21.6%)	13 (21.3%)				
Neurosurgery	33 (19.3%)	5 (8.2%)				
Orthopaedic Surgery	49 (28.7%)	26 (42.6%)				
Orthopaedics –Spinal	15 (8.8%)	3 (4.9%)				
Paediatric Surgery	6 (3.5%)	0 (0%)				
Other[þ]	6 (3.5%)	1 (1.6%)				

† p-values reported except in cases of odds ratios where 95% confidence intervals are reported;
‡ Cox regression for continuous variables;
§ LOS = Length of Stay;
¶ % of those that had surgery;
þ these were ENT, Vascular, Maxillofacial, Plastics, Urology and unknown.

a TTA compared to those who met the criteria but did not have a TTA (12.8 [SD=58.6] vs 6.4 [SD=3.7]; p=0.027). There was no significant difference in ED LOS (hours) (3.8 [SD=2.8] vs 4.9 [SD=3.4]; p=0.119). There was no significant difference in admission to ICU (OR 2.09; 95%CI:0.67–6.50); however, patients with a TTA trended insignificantly towards a longer ICU LOS (days) (11.1 [SD=12.7] vs 5.3 [SD=3.4]; p=410). There was no significant difference for requiring surgery (OR 1.28; 95%CI:0.50–3.26) and time to surgery did not differ significantly between groups (p=0.56).

Multivariate analyses were conducted controlling for age and ISS looking at mortality, time to CT, ED LOS, hospital LOS, admission to ICU, ICU LOS and whether surgery was required for patients who received a TTA vs patients who did not receive a TTA but met criteria. Once age and ISS were controlled for, there continued to be no significant difference in mortality (OR 0.43; 95%CI:0.07–2.73). There continued to be no significant difference in ED LOS (hours) (p=0.259). Hospital LOS (days) remained significantly longer for TTA patients (p=0.012). There continued to be no significant difference in admission to ICU (OR 1.42; 95%CI:0.44–4.50), ICU LOS (days) (p=0.34), or requirement of surgery (OR 1.38, 95%CI: 0.53-3.60) (see Appendix 2).

Discussion

Christchurch Hospital uses a two-tier trauma team activation system to ensure that a full multi-professional trauma team are available to rapidly attend to critically injured major trauma patients, while reducing the resources and staff for the less severely injured trauma patient. This two-tier system aims to reduce unnecessary involvement of specialist teams, and protect this limited resource for more serious cases.

During the one-year period reviewed those that had a trauma team activation had a higher mean ISS compared to those without a TTA. Patients with a full Trauma Call also had higher mean

ISS than those with a Trauma Standby. As ISS is officially calculated after the patient has been fully assessed, this suggests that patients with more severe injuries are being appropriately recognised early in their healthcare journey.

It is reassuring that the TTA process is not biased by either gender or ethnicity. However, patients over 64 years of age were markedly less likely to receive a TTA, suggesting a potential under-appreciation of injuries in this age group. Older adults were also less likely to have a full Trauma Call if they did receive a TTA. This is concerning as multiple previous studies have found that even after adjusting for injury severity and pre-existing medical conditions, older trauma patients have consistently worse outcomes, with twice the mortality and significantly longer ICU and hospital length of stay.[19–23] The Christchurch TTA system does not currently contain any age-specific criteria, which has been shown to improve the identification of injured older adults.[24,25] In addition studies have shown that the care of elderly trauma patients is an area of research that trauma clinicians have previously identified as a research priority to improve care of these patients.[26] This is currently being investigated by our study team.

Road traffic crashes accounted for the majority of TTAs, with 43.9% of TTAs being a combination of road traffic crashes and motorbike crashes. This finding is similar to the caseload proportions identified when the New Zealand Major Trauma Registry was first implemented. At the time 50% of all trauma caseload was accounted for by road traffic crashes.[27] Further research into the mechanism of injury of trauma presenting to Christchurch Hospital over a longer timeframe would be valuable to aid public health policy initiatives.

The primary multivariate analysis which controlled for both ISS and age showed that TTA was associated with decreased time to CT, time to surgery and ED LOS, despite these patients having an increased rate of requirement for surgery, admission to ICU and longer ICU LOS. This suggests that TTAs may be associated with improving rapid assessment and management on presentation to hospital. After controlling for age and ISS, there was no longer a significant difference in mortality for patients with a TTA vs those with no TTA. There may be a number of reasons for this; however, the under-recognition of major trauma in older adults, who have higher mortality rates that younger patients with similar injuries, will be confounding this issue.

Patients who received a full Trauma Call, as compared to Trauma Standby, had a higher mortality after controlling for ISS and age. It is not clear whether there are other factors not captured by ISS and age that are affecting this group. A further investigation is warranted to determine whether there are specific patient groups that would benefit from a full Trauma Call, as well as a cost-benefit analysis of activation of the full multi-professional trauma team.

Limitations

The retrospective and observational nature of this study incurs standard limitations in data collection and interpretation. Due to the retrospective and observational nature of our study causality cannot be inferred. The number of cases in some of the subgroup analyses is small which may limit statistical power. The CDHB Major Trauma Database does not record those patients who have a TTA but are not finally coded as having major trauma, and so the rate of false positive TTAs is not known. A limitation of our dataset is the absence of data regarding trauma patients who are not classified as major trauma (ISS<12). This data is not collected within the CDHB trauma database due to resource constraints. Another limitation of our data is the absence of data regarding patients who are directly transferred from ED to the operating theatre. This data would be valuable to evaluate in further studies.

Conclusions

The Christchurch Hospital Trauma Team Activation system is associated with reduced time to diagnostic imaging and definitive management in surgery of major trauma patients presenting to Christchurch Hospital. The current two-tier activation process requires review to determine if there are certain patient groups who do not require the full Trauma Call and could therefore have similar benefit from a Trauma Standby, without the associated resourcing costs.

An additional tier of TTA will shortly be introduced in Christchurch, for the most critically injured patients. “Code Crimson” will increase the number of senior clinicians attending TTAs for patients with immediately life-threatening haemorrhage due to trauma, and a review of the outcomes of all major trauma patients after this process change will be essential.[28] The addition of age-specific criteria to the current protocol should be considered due to the under-triage and under-diagnosis of older adults with major trauma who have significantly higher mortality and morbidity.

COMPETING INTERESTS
Nil.

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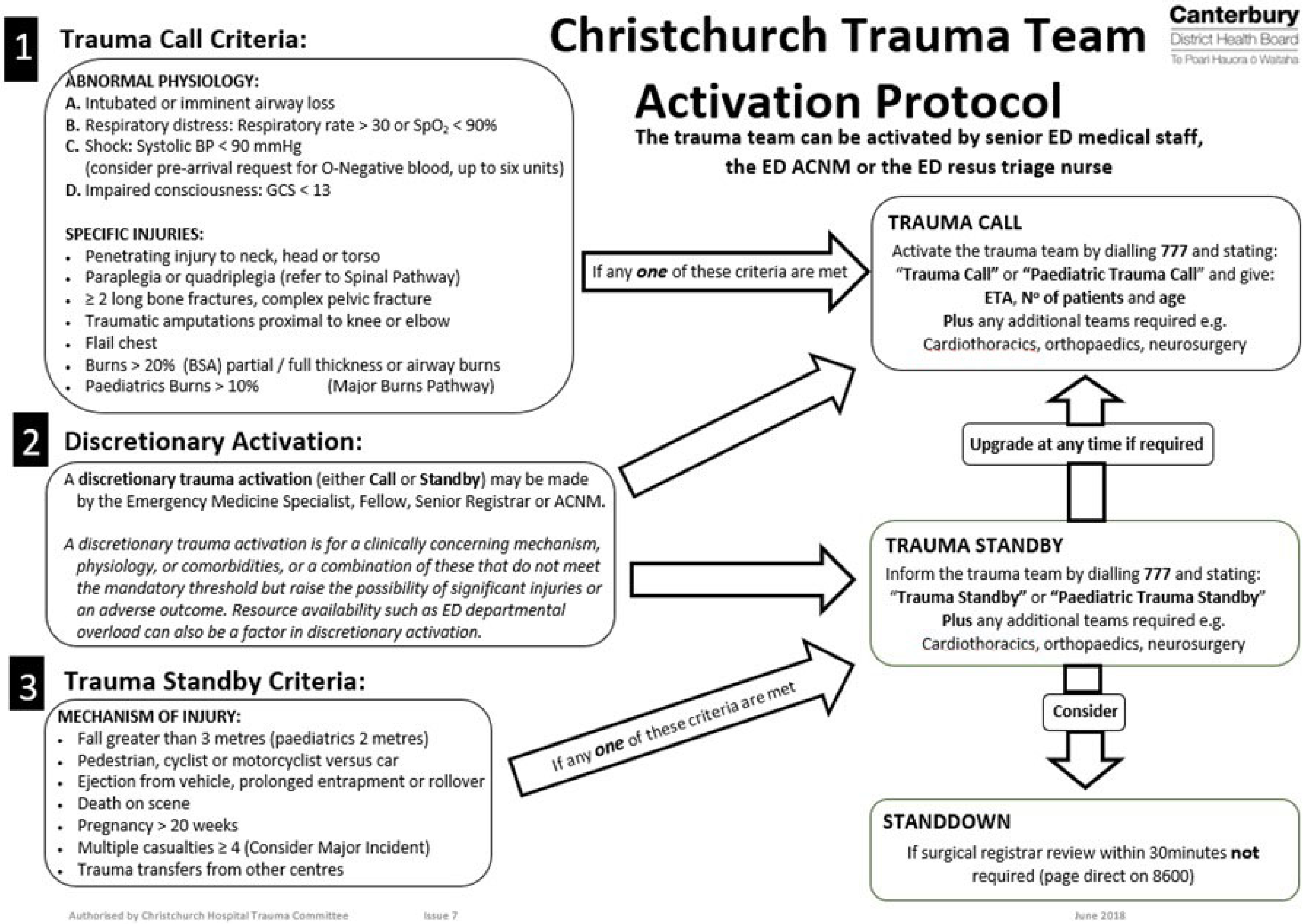
Appendices

Appendix 1: Christchurch Trauma Team Activation protocol.



Appendix 2: ISS and key performance indicators for major trauma patients who had a Trauma Team Activation vs those who didn't, but met Trauma Team Activation criteria.

Variable	Trauma Team Activation Mean [SD] or n (%) (n=232)	No Trauma Team Activation, but meeting criteria (n=19)	Univariate statistical test	Univariate result†	Multivariate statistical test	Multivariate model controlling for age and ISS
ISS‡	21.1 [8.7]	18.1 [4.9]	Mann–Whitney U test	p=0.169	NA	NA
Age						
<65	196 (84.5%)	15 (78.9%)	Odds Ratio	OR 0.69 (95% CI: 0.22–2.19)	NA	NA
65+	36 (15.5%)	4 (21.2%)				
Mortality	17 (7.3%)	2 (10.5%)	Odds Ratio	OR 0.67 (95% CI: 0.14–3.15)	Logistic regression	OR 0.43 (95% CI: 0.07–2.73)
Time to CT (mins)	86.6 [97.3]	162.1 [144.7]	Mann–Whitney U test	p<0.001	Cox regression	p=0.007§
	Median=60	Median=116	Mann–Whitney U test	p<0.001		
ED LOS¶ (hours)	3.8 [2.8]	4.9 [3.4]	Mann-Whitney U test	p=0.119	Cox regression	p=0.259§
Admission to ICU	83 (35.8%)	4 (21.1%)	Odds Ratio	OR 2.09 (95% CI: 0.67-6.50)	Logistic regression	OR 1.42 (95% CI: 0.44–4.50)
ICU LOS¶ (days)	11.1 [12.7]	5.3 [3.4]	Mann–Whitney U test	p=0.410	Cox regression	p=0.134§
Hospital LOS¶ (days)	12.8 [58.6]	6.4 [3.7]	Mann–Whitney U test	p=0.027	Cox regression	p=0.012§
Surgery	136 (58.6%)	10 (52.6%)	Odds Ratio	OR 1.28 (95% CI: 0.50–3.26)	Logistic regression	OR 1.38 (95% CI: 0.53–3.60)
Time to surgeryþ						
<24hrs	73 (53.7%)	6 (50.0%)	Mann–Whitney U test	p=0.56	NA	NA
24–48hrs	24 (17.6%)	2 (20.0%)				
48–72hrs	11 (8.1%)	2 (20.0%)				
>72hrs	28 (20.6%)	1 (10.0%)				

† p-values reported except in cases of odds ratios where 95% confidence intervals are reported; ‡ Injury Severity Score available for 225 TTA and 19 no TTA, but meeting criteria; § Cox regression for continuous variables; ¶ LOS= Length of stay; þ % of those that had surgery.