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ORIGINAL RESEARCH

Retrospective validation of a risk stratification tool developed for the management of patients with blunt chest trauma (the STUMBL score)

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Abstract

Objective: To assess validity of the STUMBL score in New Zealand for complications of blunt chest trauma without multi-trauma and immediate life-threatening injuries.

Methods: A multi-centre, retrospective observational study was carried out in five EDs. Area under the receiver operating characteristic curve (AUROC) was calculated for all, early and late complications and ethnic sub-groups. Youden Index generated for each ROC was used to indicate cut scores for risks of complication, ICU admission, prolonged length of stay (LOS) and mortality.

Results: A total of 445 patients were included. AUROC for all complications composite were (0.73, 95% confidence interval [CI] 0.68–0.77), mortality (0.92, 95% CI 0.89–0.94), ICU admissions (0.78, 95% CI 0.73–0.81) and prolonged LOS (0.80, 95% CI 0.76–0.83) were calculated. The score performed better in the New Zealand European (Pākehā) subgroup compared to Māori and Pasifika (AUROC [95% CI]: 0.80 [0.73–0.85], 0.69 [0.56–0.79], 0.66 [0.46–0.82], respectively). Patients with scores >12 were at risk of complications from blunt chest trauma, >15 at risk of prolonged LOS and >18 at risk of ICU admission and mortality.

Conclusions: The STUMBL score at a cut-off of <12 did not predict all complications sufficiently well to recommend for general use in our population. However, a score >15 predicted prolonged LOS and a score >18 predicted mortality sufficiently to be clinically useful for these outcomes. The score is more accurate in New Zealand Pākehā and needs to be used with caution in Māori and Pasifika populations. A larger prospective validation is required to further assess the score.

Key words: *blunt chest trauma, blunt chest trauma score, risk stratification, STUMBL score.*

Key findings

- This is the first instance outside of the UK to validate the STUMBL score's predictive capabilities of mortality and morbidity in isolated blunt chest trauma patients presenting to the ED.
- A STUMBL score >15 predicted prolonged LOS and the need for ICU admission and a score >18 predicted mortality sufficiently to be clinically useful for these outcomes.
- The score is more accurate in New Zealand Pākehā and needs to be used with caution in Māori and Pasifika populations.

Introduction

Thoracic injuries are a major cause of trauma related mortality globally, with a reported range of 4–60%.[1–5] Accurate evaluation of the level of severity of thoracic trauma is important for predicting outcome and management. Several prognostication scores, including the Trauma and Injury Severity Score and the Thoracic Trauma Severity Score, exist for blunt chest trauma. However, most are designed for use in patients with multiple, severe or life-threatening injuries and very few have been externally validated.[6,7] In less severe blunt chest trauma, there is also ambiguity regarding potential risk factors for adverse outcome and there is a lack of national guidelines available.[8–10] This makes managing patients with

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blunt chest trauma without immediate life-threatening injuries problematic for the clinician.[11] There is an acute need for a prognostication score for managing this group of patients.

A clinical score has been developed in UK EDs to predict the risk of complications after blunt chest trauma in patients without multi-trauma and immediate life-threatening injuries (STUdy evaluating the impact of a prognostic model for Management of Blunt chest wall trauma patients: STUMBL trial [STUMBL score], Appendix S1).[12,13] The model comprises several risk factors and the patient is scored on each (Appendix S1). The authors reported a final risk score of ≥11 was the most accurate cut-off at which patients were considered at risk of developing complications. A final total risk score of >25 was considered high enough to require intensive care unit (ICU) admission.[12] The original study reported an area under the receiver operating characteristic curve (AUROC) of 0.8 (95% confidence interval [CI] 0.75–0.85).[12] The STUMBL score has since been externally validated in seven hospitals in England and Wales with a AUROC of 0.96 (95% CI 0.93–0.98) and a final model sensitivity of 80%, specificity of 96%.[12]

As it was not known whether the score would perform equally well in our setting, we believed a validation in New Zealand healthcare setting was required. The aim of the present study was to perform a retrospective validation of the STUMBL score in New Zealand.

Methods

Study design and population

A multi-centre, retrospective observational study was carried out. Data was captured from the ED of three Major Referral Centres, one Urban District Hospital and one Rural/Regional Centre. Patients were identified using a standardised list of International Classification of Disease, 10th revision (ICD10) codes for any chest trauma presenting to the ED. Chart reviews were carried out to identify and include patients aged 18 years or older who were given a final primary diagnosis of isolated blunt chest trauma. Patients with penetrating chest trauma, immediate life-threatening injuries or multi-trauma (defined as any concurrent injuries sustained during the trauma event, in addition to chest trauma, that will significantly determine the patient's management and outcome) were excluded.

Based on the sample size calculation, four larger sites had a target of 100 patients, while the fifth site had a target of 50. Each site performed retrospective chart reviews of sequential included patients, starting from the most recent presentation. A data abstraction form was initially piloted at one site. With feedback the form was improved and standardised. A data dictionary was devised and where appropriate, incorporated within the standardised data abstraction form to help improve abstraction accuracy and ensure uniform handling of data that were conflicting or ambiguous. This standardised form was then utilised at each site to abstract data. The abstracted data were all mandatory clinical information normally recorded as part of standard clinical care. Patients were excluded from analysis on the rare occasion where there was significant missing data, defined as missing data for variables that were required to calculate the primary and secondary outcomes.

Data were abstracted by emergency medicine doctors and nurses, who were trained locally on how to abstract data accurately and how to handle conflicting, ambiguous or missing data. Abstractors were in regular contact with the senior investigator locally to help clarify and resolve data abstraction and data handling conflicts. Most abstractors were aware of the STUMBL score but had no familiarity with it in clinical practice. Abstractors were blinded to score calculation, variable weighting and score performance, especially with regards to score cut-offs. Further, all score components and outcomes were objective, which reduced risk of bias. Data management and accuracy checks were conducted locally, where the senior investigator at each site carried out a manual check on a random portion of the data. For a 10% sample of the total cohort, the inter-investigator agreement was 96.4% for STUMBL score variables and 99.3% for outcome variables. A kappa statistic of 0.93 (95% CI 0.90–0.95) (n = 270) was calculated for six categorical variables, indicating an almost perfect agreement for inter-investigator reliability. The senior investigators at each site were in regular contact with each other and the principal investigator to help resolve disputes and clarify ambiguity in data handling and coding. Data were de-identified as soon as viable and was sent to the coordinating investigator and the study biostatistician for further analysis. The study biostatistician was independent of the authors who planned and coordinated the study.

Because of varying presentation rates at each site and a staggered site recruitment, each site had a different start date and duration over which their patients were identified and enrolled. The time point when the first patient presented at each site were as follows: July 2013, January 2016, December 2016, June 2017 and April 2018.

Outcomes

The primary outcome was to assess the validity of the STUMBL score for all complications of chest blunt trauma, originally defined by the STUMBL authors as a composite of:[12]

- In-hospital mortality.
- All pulmonary complications (including but not restricted to haemothorax, pneumothorax, lung contusion, pneumonia, and empyema, excluding rib fractures).
- Need for ICU admission.
- Prolonged hospital stay defined as a total hospital stay of 7 days or more.[2]

The above primary outcome was selected to mirror the British validation of the STUMBL score and hence allow a direct comparison.

Secondary outcomes validated the STUMBL score using a composite of early and delayed complications. Early complications were defined as:

- Presence of a pulmonary complication on arrival to ED as defined above.
- Admission to ICU from ED.

Delayed complications were defined as:

- Delayed pulmonary complications defined as pulmonary complications developing or discovered after discharge from the ED to the ward or community, including lung contusion, pleural effusion, empyema, hemothorax, pneumothorax, pneumomediastinum, pneumonia or pulmonary embolism.
- Delayed escalation in care, defined as a requirement for ICU admission because of chest trauma-related complications at any point after discharge from the ED to the ward or community.
- Unplanned re-presentation to the ED – Patient discharged from ED on the first presentation but re-presented to ED with complications of chest trauma that was not a planned follow-up assessment within 72 h of discharge for patients whose initial hospital stay was 1 day or less (including those discharged directly from ED and those admitted to a ward for less than 2 days).

The final secondary outcome was to validate the score for Māori, Pasifika and New Zealand European (Pākehā) population sub-groups.

Statistical analysis

Diagnostic test accuracy is demonstrated by the AUROC with a value of 0.5 considered worthless, while a value more than 0.8 is considered good for a test to predict outcome.[14,15] Based on a conservative estimate of complication rate of 33%, to show that the AUROC of 0.8 is statistically significantly better than 0.5 with 90% power and an alpha of 0.05 we required 39 cases of chest wall trauma (MedCalc Statistical Software version 17.8.6, Ostend, Belgium; http://www.medcalc.org 2017).[3,12] In order to provide sufficient explanatory power for Māori and Pasifika patients, who comprise 15% and 9% of the population in New Zealand, the authors determined that the overall sample should be 440 participants (39/0.09 = 433).[16,17]

TABLE 1. *Baseline characteristics of the study participants*

Characteristics	Frequency, *n* = 445
Age, mean (SD) (years)	57 (21)
Female gender, *n* (%)	151 (33.9)
Chronic lung disease, *n* (%)	74 (16.6)
Current smoker, *n* (%)	101 (24.2)
Pre-injury anticoagulant use, *n* (%)	94 (21.1)
Mechanisms of injury, *n* (%)	
Fall	225 (50.6)
Road traffic collision	135 (30.3)
Sports	39 (8.8)
Assault	30 (6.7)
Crush injuries	13 (2.9)
Low velocity impacts	3 (0.9)
Ethnicity, *n* (%)	
NZ European/Pākehā	200 (44.9)
Other European	111 (24.9)
Māori	70 (15.7)
Pasifika	30 (6.7)
Asian	25 (5.6)
Other	9 (2.6)

Descriptive statistics was used to show the baseline characteristics for continuous variables. ROCs were generated for the study outcomes, AUROC were calculated and the Youden Index was generated for each AUROC. The maximum value of the Youden Index was used as the optimum cut score for each outcome.[14,15]

Ethics approval

Ethics approval was granted by the Health and Disability Committees (ref:19/NTA/13) and Research Advisory Group Māori (RAG-M).

Results

Four hundred and fifty sequential patients were identified with five patients excluded during the analysis because of incorrect or inadequate data capture. The average age (SD) was 57 (21) years with 33.9% being female (Table 1). Falls and road traffic collisions were the primary reasons for injury, accounting for more than 80% of the patients (Table 1).

In-hospital mortality was 1.1%, with associated risk scores of 19, 23, 25, 32 and 32. More than 65% had severity scores of less than 16 (Table 2). Admission to a ward was required for 55%, while 5.6% of patients were admitted to ICU at initial presentation (Table 2). Twenty-eight patients had a delayed pulmonary complication and four had a delayed escalation of care to ICU with an average length of stay (LOS) in ICU (SD) of 2 (1.4) days.

STUMBL score validation

The AUROC (95% CI) for all complications composite outcome and in-hospital mortality were 0.73 (0.68–0.77) and 0.92 (0.89–0.94) (Fig. 1). The AUROC (95% CI) for early complications composite outcome, initial ICU admission and early pulmonary complications were 0.66 (0.59–0.70), 0.78 (0.74–0.82) and 0.66 (0.62–0.71), respectively. Delayed complications composite, delayed pulmonary complications, delayed escalation of care and

TABLE 2. *Complications at presentation*

Characteristics, *n* (%)	Frequency, *n* = 445
In-hospital mortality at any time	5 (1.1)
Patients with lung complications at presentation	104 (23.4)
CT performed (*n* = 442)	189 (42.8)
Complications on CT only (of those who had a CT)	124 (65.6)
Number of rib fractures (*n* = 443), *n* (%)	
0	91 (20.5)
1	141 (31.8)
2	63 (14.2)
3	62 (14.0)
4	33 (7.5)
5	23 (5.2)
>5	30 (6.8)
Lung complications at presentation, *n* (%)	
Nil	341 (76.6)
Pneumothorax	58 (13.1)
Hemothorax	17 (3.8)
Lung contusion	16 (3.6)
Haemopneumothorax	9 (2.0)
Lung consolidation/atelectasis	4 (0.9)
Surgical emphysema	3 (0.7)
Pneumonia	3 (0.7)
Pneumomediastinum	2 (0.5)
Flail segment	2 (0.5)
Pleural effusion	2 (0.5)
Lung laceration	1 (0.2)
STUMBL score cut-offs, *n* (%)	
0–10	181 (40.7)
11–15	115 (25.8)
16–20	72 (16.2)
21–25	51 (11.5)
26–30	18 (4.0)
>30	8 (1.8)
Disposition	
Discharged home from ED, *n* (%)	175 (39.3)
Admitted to ward, *n* (%)	245 (55.3)
Admitted to ICU, *n* (%)	25 (5.6)
Average ward LOS, *n* (SD) (days)	5.6 (5.4)†
Average ventilator days, *n* (SD) (days)	3.2 (1.7)‡
Average ICU/HDU LOS, *n* (SD) (days)	3.2 (2.6)§

†Range 1–26 days. ‡Range 1–6 days. §Range 1–13 days.

unplanned re-presentation to ED had associated AUROC (95% CI) of 0.66 (0.61–0.71), 0.69 (0.65–0.74), 0.75 (0.71–0.79) and 0.62 (0.57–0.67), respectively.

Cut scores and risk thresholds

The Youden Index for all complications composite was associated with a total cut score of >12 (sensitivity 61.7%, specificity 72.4%). A score of >18 was the threshold for admission to ICU (sensitivity 65%, specificity 80.3%) and mortality (sensitivity 100%, specificity 78.9%). The Youden Index for the prolonged LOS AUROC had an associated risk score of >15 (sensitivity 73.3%, specificity 76.0%).

Sub-group analysis: ethnicity

Sub-group analysis was carried out for all complications composite outcome for Māori, Pasifika, New Zealand Pākehā and Asian patients. There was no mortality in Māori, Pasifika or Asian groups and no ICU admissions in the Pasifika and Asian groups.

The AUROC (95% CI) for all complications composite outcome in Pākehā, Māori, Pasifika and Asian groups were 0.80 (0.73–0.85), 0.69 (0.56–0.79), 0.66 (0.46–0.82) and 0.74 (0.53–0.89), respectively (Appendix S2). The components of the composite outcome AUROC in the Pākehā group were generally greater than 0.8 (Appendix S2).

The AUROC (95% CI) for prolonged LOS in Māori, Pākehā, Pasifika and Asian groups were 0.95 (0.87–0.99), 0.80 (0.74–0.86), 0.87 (0.70–0.96) and 0.80 (0.59–0.93), respectively.

Discussion

This was the first independent validation of the STUMBL score outside the UK. Overall, the score's ability to predict all complications fell short of an AUROC of 0.8 that is accepted as the cut-off for a strong model[14,15] and well short of the AUROC of 0.96 reported in the UK external validation.[12] However, when the STUMBL

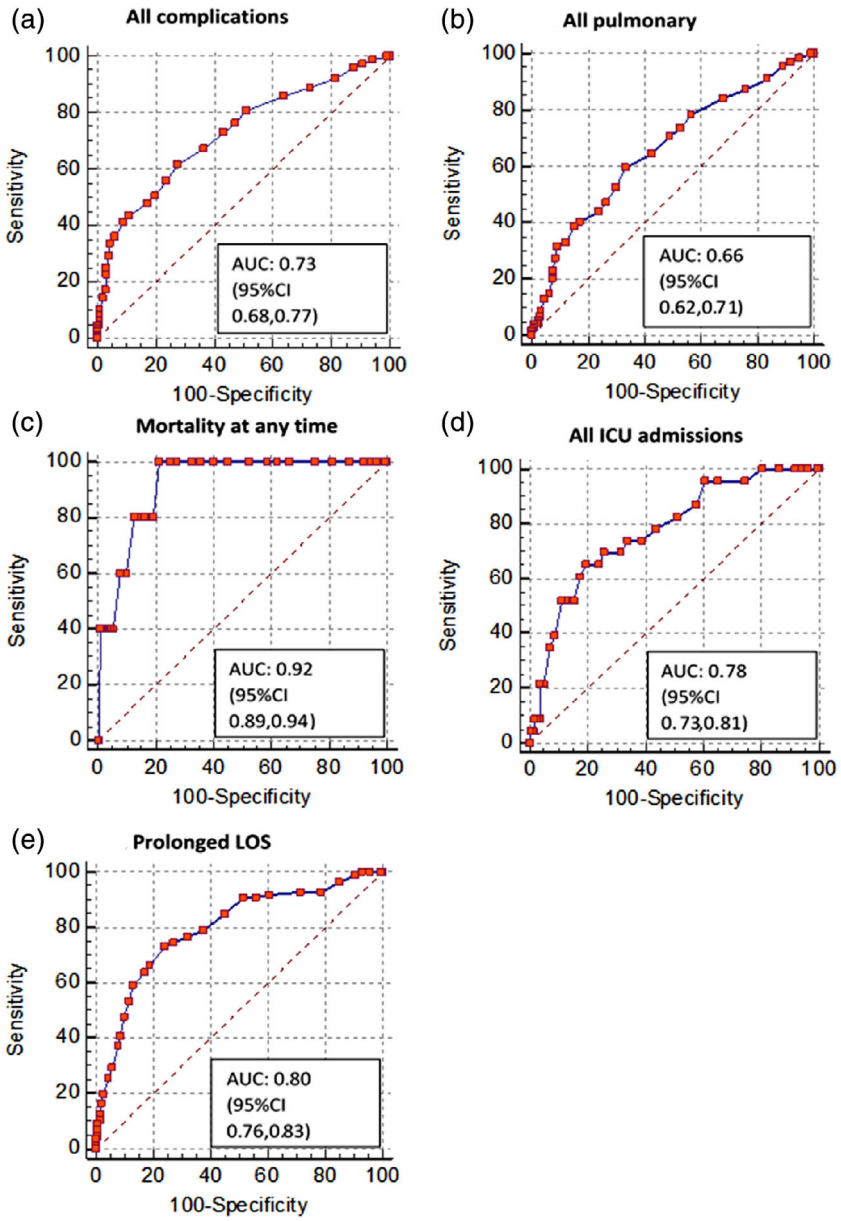

Figure 1. *(a–e) AUROC for all complications composite, all pulmonary complications, mortality at any time, ICU admission at any time and all prolonged length of stay of greater than 7 days.*

score was assessed for the individual components of the composite outcome, the score was excellent at predicting in-hospital mortality, and good at predicting prolonged LOS. The STUMBL score was very good at predicting ICU admission in the Māori and Pākehā sub-groups. The score performed better in the Pākehā sub-group for all complications composite outcome, compared to the other sub-groups.

There are several reasons why the score did not perform as well as it did in the UK. Firstly, the UK validation cohort had potentially more comorbidities with slightly higher rates of smokers and patients with chronic lung diseases (Appendix S3). However, age, gender and rates of pre-injury anticoagulant use were almost identical. Further, approximately 50% of patients in both cohorts had either one or no rib fracture, suggesting a similar injury severity in both groups.

Secondly, there are inherent differences between medical services and in-hospital protocols for trauma management, which may have had an impact on the final outcome and generalizability of the score. For example, the rates of computed tomography (CT) imaging of this sample and the original UK sample were different (43% *vs* 3%).[12] The higher CT rates in our sample would have allowed for a better pick-up rate of more subclinical injuries and pulmonary complications in lower score groups, which may explain the poor predictive capacity of the score for pulmonary complications noted in the present study. Similarly, with a higher CT rate, our study is likely to have had more accurate rib fracture data than clinical estimates of the number of fractures.

The generalisability of the score to New Zealand population may be somewhat further limited because of differences in ethnic groups between the UK and New Zealand cohorts. The score performed better in the Pākehā cohort and may suggest that it may not be generalisable to certain ethnic groups.

There were also some differences in the score thresholds for clinical decision making. The original study suggested a score of ≤11 for discharging patients from ED and a score of >25 for admission to ICU. Our data similarly suggested an admission threshold of >12. Patients with scores of >15 were more likely to have a prolonged LOS. However, our data indicated a lower threshold for admission to ICU (>18 *vs* >25). This may have been due to inherent differences in ICU admission practices between sites. Patients from the original sample were automatically admitted to the ICU only if they required invasive analgesics, such as an epidural.[12] Conversely, at least one hospital in the present study electively admitted patients with blunt chest trauma to ICU for observation based on clinical assessment of injuries rather than physiological markers. Further, at least one other hospital in the present study had poor access to High Dependency

Unit beds and routinely admitted patients to ICU if the patient was deemed to require High Dependency Unit level care.

Limitations

There are inherent biases in retrospective studies. Selection bias was reduced by having strict inclusion and exclusion criteria. A comprehensive list of ICD10 codes was used to standardise the search terms to identify patients. However, the different sites had different database interfaces, which required using slightly different free text search terms. This may have caused some injury codes to be missed at some sites.

There was significant heterogeneity of the time point when the first patient presented at each site. There may have been changes in trauma service provision and per site protocol changes in the duration over which the patients were identified at each site. This may have had an impact on the final result. And finally, the study was underpowered for Pasifika and Asian subgroups, hence results need cautious interpretation.

Conclusion

We validated the STUMBL score in New Zealand showing that a cut-off of <12 did not predict all complications sufficiently well to recommend for general use in our population. However, a score of >15 predicted prolonged LOS and >18 predicted mortality sufficiently to be clinically useful for these outcomes and came close to being a good predictive model for ICU admission. The STUMBL score can aid the clinician in predicting mortality, prolonged hospital stay and overall need for ICU level care in less severe, isolated blunt chest trauma patients. A prospective validation across multiple sites in New Zealand, that is sufficiently powered for ethnicity subgroup analysis, is required to further validate the score.

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Author contributions

PJ, CM and SM conceived the study, designed the trial and obtained ethics approval. PJ, SM, ET, PB and KP supervised the conduct of the trial and data collection locally. CM, HM, ET and CM collected data at individual sites. PJ and SM provided statistical advice on study design and data analysis. SM drafted the manuscript and all authors contributed substantially to its revision. SM takes responsibility for the paper as a whole.

Competing interests

PJ is a section editor for *Emergency Medicine Australasia*.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. Battle CE, Hutchings H, Evans PA. Risk factors that predict mortality in patients with blunt chest wall trauma: a systematic review and meta-analysis. *Injury* 2012; **43**: 8–17.
2. Martinez Casas I, Amador Marchante MA, Paduraru M *et al*. Thorax trauma severity score: is it reliable for patient's evaluation in a secondary level hospital? *Bull. Emerg. Trauma* 2016; **4**: 150–5.
3. Battle CE, Hutchings H, James K, Evans PA. The risk factors for the development of complications during the recovery phase following blunt chest wall trauma: a retrospective study. *Injury* 2013; **44**: 1171–6.
4. Brasel KJ, Guse CE, Layde P, Weigelt JA. Rib fractures: relationship with pneumonia and mortality. *Crit. Care Med.* 2006; **34**: 1642–6.
5. Bergeron E, Lavoie A, Clas D *et al*. Elderly trauma patients with rib fractures are at greater risk of death and pneumonia. *J. Trauma* 2003; **54**: 478–85.
6. Ahmad MA, Sante ED, Giannoudis PV. Assessment of severity of chest trauma: is there an ideal scoring system? *Injury* 2010; **41**: 981–3.
7. Moon SH, Kim JW, Byun JH *et al*. The thorax trauma severity score and the trauma and injury severity score: do they predict in-hospital mortality in patients with severe thoracic trauma?: a retrospective cohort study. *Medicine* 2017; **96**: e8317.
8. Sawa J, Green RS, Thoma B, Erdogan M, Davis PJ. Risk factors for adverse outcomes in older adults with blunt chest trauma: a systematic review. *CJEM* 2018; **20**: 614–22.
9. Söderlund T, Ikonen A, Pyhältö T, Handolin L. Factors associated with in-hospital outcomes in 594 consecutive patients suffering from severe blunt chest trauma. *Scand. J. Surg.* 2015; **104**: 115–20.
10. Liman ST, Kuzucu A, Tastepe AI, Ulasan GN, Topcu S. Chest injury due to blunt trauma. *Eur. J. Cardiothorac. Surg.* 2003; **23**: 374–8.
11. Blecher GE, Mitra B, Cameron PA, Fitzgerald M. Failed emergency department disposition to the ward of patients with thoracic injury. *Injury* 2008; **39**: 586–91.
12. Battle CE, Hutchings H, Lovett S *et al*. Predicting outcomes after blunt chest wall trauma: development and external validation of a new prognostic model. *Crit. Care* 2014; **18**: R98.
13. Battle C, Abbott Z, Hutchings HA *et al*. Protocol for a multicentre randomised feasibility STUdy evaluating the impact of a prognostic model for management of BLunt chest wall trauma patients: STUMBL trial. *BMJ Open* 2017; **7**: e015972.

14. Tape TG. University of Nebraska Medical Centre. [Cited 9 Jan 2019.] Available from URL: http://gim.unmc.edu/dxtests/roc3.htm
15. Hoo ZH, Candlish J, Teare D. What is a ROC curve? *Emerg. Med. J.* 2017; **34**: 357–9.
16. Reid P, Paine SJ, Curtis E *et al.* Achieving health equity in Aotearoa: strengthening responsiveness to Māori in health research. *N. Z. Med. J.* 2017; **130**: 96–103.
17. Stats NZ. 2018 Census. [Cited 18 Dec 2019.] Available from URL: https://www.stats.govt.nz/2018-census/

Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Appendix S1. STUMBL score.[12,13]
Appendix S2. AUROC for blunt chest trauma complications in Māori (Fig. S1) and Pākehā (Fig. S2).
Appendix S3. Baseline characteristics of the present study population compared to STUMBL validation sample.[12]