Archives of Academic Emergency Medicine. 2025; 13(1): e37

OPEN ACCESS

ORIGINAL RESEARCH

Predicting the Need for Tertiary Trauma Care Using a Multivariable Model: A 4-Year Retrospective Cohort Study

Piraya Vichiensanth[1], Kantawat Leepayakhun[1], Chaiyaporn Yuksen[1], Chetsadakon Jenpanitpong[2]*, Suteenun Seesuklom[2]

1. Division of Emergency Medicine, Department of Emergency Medicine, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok 10400, Thailand

2. Division of Paramedicine, Department of Emergency Medicine, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok 10400, Thailand

Received: January 2025; Accepted: February 2025; Published online: 10 March 2025

Abstract: **Introduction:** Delays in accessing an appropriate level of care can lead to significant morbidity or even mortality of trauma patients. This study aimed to develop a simplified prehospital predictive model to determine the need for tertiary care trauma centers (TTC), enabling timely and appropriate transport decisions by emergency medical service (EMS) teams. **Methods:** This is a retrospective cohort study conducted at the emergency department (ED) of Ramathibodi Hospital between January 2020 and April 2024. Prehospital trauma patients aged ≥15 years who were transported by EMS were included in the study. Patients were divided into two groups with and without the need for TTC, and the independent predictive factors of the need for TTC were explored using multivariable regression analysis. **Results:** The study included 440 trauma patients, with 31.1% requiring TTC. The predictors of the need for TTC included age (coefficient (Coef.) -0.003; 95% confidence interval (CI): -0.018 to 0.012; P=0.693), traffic mechanism (Coef. 0.848; 95%CI: 0.150 to 1.546; P=0.017), respiratory rate (Coef. 0.044; 95%CI: -0.037 to 1.124; P=0.285), heart rate (Coef. -0.004; 95%CI: -0.020 to 0.012; P=0.610), and Glasgow Coma Scale (Coef. -0.312; 95%CI: -0.451 to -0.173; P<0.001). The predictive model categorized patients into low, moderate, and high-risk groups. Patients who were categorized in the high-risk group showed a positive likelihood ratio (LHR+) of 14.88 for requiring TTC. The model achieved an area under the receiver operating characteristic curve (AuROC) of 73%, indicating the good discriminative ability of this prediction model. **Conclusion:** The predictive model classifies trauma patients into three risk groups based on five prognostic variables, which are able to predict the likelihood of requiring TTC. Internal validation has verified its high level of accuracy in trauma triage.

Keywords: Injuries; Emergency medical services; Triage; Trauma severity indices; Trauma centers

Cite this article as: Vichiensanth P, Leepayakhun K, Yuksen C, et al. Predicting the Need for Tertiary Trauma Care Using a Multivariable Model: A 4-Year Retrospective Cohort Study. Arch Acad Emerg Med. 2025; 13(1): e37. https://doi.org/10.22037/aaemj.v13i1.2581.

1. Introduction

Traumatic injury remains one of the leading causes of death worldwide (1). In 2021, unintentional injuries accounted for 224,935 deaths (6.5%), making it the fourth leading cause of mortality in the United States (2). Globally, millions of individuals are affected by traumatic injuries, including those resulting from motor vehicle collisions, violent assaults, accidental falls, and fire-related incidents. While some injuries require only basic medical treatments, others necessitate advanced surgical interventions (3, 4). Delays in accessing an appropriate level of care can lead to significant morbidity or even mortality. Emergency Medical Services (EMS) are critical in assessing and transporting injured patients to facilities that provide the necessary care (5).

In Thailand, an 11-year retrospective study that analyzed data from 35,724 patients with traumatic out-of-hospital cardiac arrests revealed that only 6,590 patients (18.45%) survived upon arrival at the emergency department (ED), whereas 29,134 patients (81.55%) were pronounced dead in the ED (6). According to data from the Thailand National Institute for Emergency Medicine in 2023, approximately 0.69 million patients with traumatic injury utilized EMS services annually, with a rising trend observed in recent years. Road traffic injuries was ranked as the second leading cause of death worldwide, with a high mortality rate of 30.5 deaths per 100,000 population recorded in 2019 (7). Notably, the majority of road traffic injury cases in Thailand are transported to the ED via EMS (8).

Emergency Medical Services (EMS) in Thailand are mainly government-operated and hospital-based. Most of these teams are Basic Life Support (BLS) units, which are typically led by emergency medical technicians or emergency medical responders. Advanced Life Support (ALS) teams, usually led

***Corresponding Author:** Chetsadakon Jenpanitpong; Division of Paramedicine, Department of Emergency Medicine, Faculty of Medicine Ramathibodi Hospital, Mahidol, 270 Rama VI Road, Thung Phaya Thai, Ratchathewi, Bangkok 10400, Thailand. Email: chetsadakon.jen@mahidol.ac.th, ORCID: https://orcid.org/0000-0001-8822-9181.

by paramedics or nurses, offer a higher level of care. At the highest level of care, comprehensive life support teams are led by emergency physicians. (9)

Due to limited capabilities and prehospital resources, significant interregional disparities in EMS coverage, and insufficient service quality, trauma patients in Thailand are often transported to the nearest hospital without consideration of the facility's specific capabilities (7). In the United States, the Field Trauma Decision Scheme (FTDS) is employed for on-scene trauma triage, assisting EMS providers in identifying the most appropriate facility for transporting trauma patients (10). However, the applicability of the FTDS may vary across countries due to differences in referral systems and healthcare facility categorizations. Further research is needed to develop tools that assist EMS providers in selecting suitable destinations for trauma patients, particularly in resource-limited settings or developing countries, including Thailand.

A previous study conducted in Thailand evaluated three trauma triage tools, including Simple Triage and Rapid Treatment (START), Revised Triage Sieve (rTS), and the National Early Warning Score (NEWS). The findings revealed that NEWS had the highest predictive ability for identifying severity in the ED, the need for a massive transfusion protocol, and admission to the intensive care unit (ICU) (11). Currently, most trauma triage tools are not specifically designed to predict a patient's need for a tertiary trauma center (TTC) (10, 12, 13). For example, the Need for Emergent Intervention within 6 Hours (NEI-6) is a predictive model designed to identify cases that necessitate the activation of trauma teams at trauma centers. It relies on prehospital parameters such as vital signs, Glasgow Coma Scale (GCS) scores, mechanism of injury, and in-hospital interventions, such as receiving five or more units of packed red cells within four hours, undergoing emergency surgery, or requiring a central line placement (3). Similarly, the Need for Trauma Intervention (NFTI) criterion predicts major trauma by assessing resource utilization, such as receiving packed red cells within four hours and ED disposition to the operating room, ICU, or interventional radiology (4). However, these tools are not explicitly tailored to predict the need for TTC, highlighting the necessity for more targeted triage models (14). Therefore, this study aimed to develop a prehospital trauma triage tool for identifying patients in need of TTC, which facilitates the appropriate transfer of traumatic injured patients to suitable trauma center facilities.

2. Methods

2.1. Study design and setting

This is a prognostic prediction model study with a retrospective cohort design conducted using electronic medical records from Ramathibodi Hospital, a university-affiliated, super-tertiary trauma facility in Bangkok, Thailand. The study period spanned from January 2020 to April 2024. Patients were divided into two groups with and without the need for TTC, and the independent predictive factors of the need for TTC were explored using Multivariable regression analysis.

Within the Ramathibodi Hospital coverage area, there are 3,500 trauma-related visits to the ED annually. The severity of traumatic injury of patients is categorized by using the Emergency Severity Index (ESI), with around 2-5% of patients classified as ESI level 1, indicating life-threatening injuries, and 30-35% classified as ESI level 2, reflecting a high risk of severe injury (15). Among these cases, 20% of patients were transported by the EMS system. Approximately 40 to 50 major trauma cases are operated on monthly, summing up to around 600 prehospital trauma cases annually.

This study was approved by the Committee on Human Rights Related to Research Involving Human Subjects, Faculty of Medicine Ramathibodi Hospital, Mahidol University (COA. NO MURA2023/477). Considering the nature of the study, which was a retrospective review of medical records, the institutional review board (IRB) waived the informed consent process. The study complies with a statement covering patient data confidentiality and the Declaration of Helsinki.

2.2. Participants

The study included adult prehospital trauma patients (aged 15 years or older) who were transported to the ED of Ramathibodi Hospital by EMS, with approximately 80% of cases treated by the Ramathibodi Hospital EMS team and the remaining cases treated by EMS teams from other hospitals within Bangkok. Patients were excluded if they were pregnant according to physiological considerations, had experienced out-of-hospital traumatic cardiac arrest, or were transferred to another hospital for further treatment.

2.3. Data collection

Eligible patients were identified through a review of electronic medical records. Data collected for each patient included demographic information (age, gender, comorbidities, and mechanism of injury), prehospital parameters including vital signs (i.e., respiratory rate, oxygen saturation, heart rate, systolic blood pressure, and GCS score), scene triage, as well as interventions performed in both the prehospital and ED settings.

2.4. Outcome

The primary outcome of the study was the need for TTC.

2.5. Definitions

Need for TCC was defined as any one of the following interventions: the activation of the massive transfusion protocol in the ED, ED disposition to the operating room or ICU, or the requirement for consultations with two or more specialists.

Airway intervention includes endotracheal intubation, supraglottic devices, and simple adjunct airways (i.e., oropharyngeal and nasopharyngeal airway).

Scene triage is defined as the triage performed by the on-scene EMS providers based on the criteria established by the Thailand National Institute of Emergency Medicine (NIEM) in 2013. Emergency patients are categorized as emergent, urgent, and non-urgent severity.

2.6. Statistical analysis

Statistical analyses were performed using STATA software version 16.0 (StataCorp, College Station, TX, USA). For comparing baseline prognostic factors, the exact probability test was used for two independent categorical variables, while the Student's t-test was used for two independent numerical variables.

To determine the discriminative performance of each candidate predictor of the need for TTC, the area under the receiver operating characteristic curves (AuROC) with 95% confidence intervals (CIs) were analyzed. Then, multivariable logistic regression with a forward selection approach was performed to develop the clinical prediction model of the need for TTC based on the statistical significance and clinical relevance of each candidate predictor.

Predictive variables were selected based on statistical findings, as well as their clinical relevance in prehospital trauma care and practicality for utilization in the prehospital setting, particularly by BLS providers. Factors that yielded good discriminative performance (AuROC of 0.6 or more) and statistically significant difference ($P < 0.05$) were selected as candidate predictors for model development.

The predicted probabilities of the clinical prediction model for TTC needs were calculated by applying the exponential or anti-logarithm function to the logistic regression modeling. Then, the predicted probabilities for TTC needs were classified into three categories based on their prognostic accuracy performances (i.e., positive likelihood ratio: LHR+) to enhance the clinical utility of the study. Calibration was presented using the Hosmer–Lemeshow goodness-of-fit test, and the calibration plot was used to determine the correlation between the predicted and observed probabilities of the clinical prediction model. A p-value of less than 0.05 was considered a statistically significant difference.

The sample size for this study was calculated from the pilot data, which compared the differences in baseline prognostic factors between prehospital trauma patients with and without the predefined outcomes. With the type-I error of 0.05, type-II error of 0.2, and the sample size ratio of 0.4, the required sample size of the study was 135.

3. Results

Initially, 480 trauma patients were identified through electronic medical records reviews. After excluding 40 patients (due to incomplete records, those who had experienced traumatic out-of-hospital cardiac arrest, pediatric patients, and pregnant women), a total of 440 cases were eligible for complete analysis. Among these patients, 137 required TTC services, while 303 did not (Figure 1).

3.1. Predictive variables of the need for TTC (Univariable analysis)

The univariable analysis, presented in Table 1, identified several variables with statistically significant associations with the need for TTC. Statistically significant differences were observed between cases with and without the need for TTC regarding age (53.72 ± 23.04 vs. 60.17 ± 23.91 years, p=0.008), female gender (33.58% vs. 48.51%, p=0.004), presence of liver diseases (6.31% vs. 1.69%, P=0.042), road traffic injury (51.85% vs. 31.23%, p<0.001), respiratory rate (20.99 ± 3.45 vs. 19.93 ± 3.90 /minutes, p=0.021), oxygen saturation (94.84 ± 7.27% vs. 96.50 ± 6.45%, p=0.049) and GCS (mild 69.23% vs. 95.11%, moderate 13.46% vs. 3.80%, and severe 17.31% vs. 1.09%, p<0.001).

Additionally, prehospital interventions demonstrated significant associations with the need for TTC, including pressure dressing (40.95% vs. 24.52%, p=0.002), airway intervention (16.51% vs. 0.45%, p<0.001), oxygen supplementation (46.36% vs. 10.45%, p<0.001), positive pressure ventilation (6.36% vs. 0.0%, p<0.001), intravenous fluid administration (42.20% vs. 8.18%, p<0.001), and spinal immobilization (63.72% vs. 26.24%, p<0.001). There was a statistically significant difference in scene triage category between patients who needed TTC and those who did not. Most patients requiring TTC were classified in the emergent triage category (65.91% vs 19.38%, p<0.001).

3.2. Development of prediction model (Multivariable analysis)

A multivariable logistic regression analysis with a forward selection approach was conducted to identify the most suitable model for predicting the need for TTC. Ultimately, five variables, including age, road traffic injury, respiratory rate (RR), heart rate (HR), and GCS, were identified as independent predictors (Table 2) and were enrolled in the final prediction model. Based on this model, the probability of the need for TTC is calculated using the following formula:

P={exp(3.135 + -0.003(Age)+ 0.848(Road Traffic Injury)+ 0.044(RR)+ -0.004(HR)+ -0.312(GCS))/(1+exp(3.135+ -0.003(Age)+ 0.848(Road Traffic Injury)+ 0.044(RR)+ -0.004(HR)+ -0.312(GCS)))}

3.3. Discriminative ability of model

The prediction model of the need for TTC demonstrates good discriminative ability, with an AuROC of 0.728 and a 95%CI of 0.663-0.793 (Figure 2). The calibration of the prediction model was evaluated using the Hosmer–Lemeshow goodness-of-fit test. The Hosmer–Lemeshow chi-squared of 8.31 and a P-value of 0.404 indicates that the logistic regression model adequately fits the data. The calibration plot also illustrates that the predicted probabilities align well with the observed outcomes (Figure 3).

The exponential function was then applied to the logistic equation to calculate the predicted probabilities of the need for TTC. We then categorized the predicted probabilities of the need for TTC into three distinct risk groups: low-risk (probability of <0.25), moderate-risk (probability of 0.25–0.65), and high-risk (probability of >0.65). The positive likelihood ratio of the need for TTC in each risk category was 0.46, 1.20, and 14.88, respectively (Table 3).

To enhance clinical utility in the prehospital setting, we also developed the need for TTC web-based calculator using Google Apps Script (Google, CA). EMS providers can access the calculator using the URL (https://bit.ly/NTTCcal) and enter the data of five predictor variables. The application will then calculate the probability of the need for TTC and recommend transport decisions (Figure 4).

4. Discussion

The prognostic model, which comprised five significant predictors, including age, road traffic injury, respiratory rate, heart rate, and Glasgow Coma Scale (GCS), was developed to predict the need for TTC among prehospital traumatic injury patients. This prediction model demonstrates good discriminative ability and good calibration for predicting the probability of the need for TTC, allowing for the classification of trauma patients into three risk categories. The positive likelihood ratio of the need for TTC was 0.46 for patients in the low-risk group (probability <0.25), 1.20 for the moderate-risk group (probability 0.25-0.65), and 14.88 for the high-risk group (probability >0.65).

Numerous studies have demonstrated that trauma patients treated in trauma centers have significantly lower mortality compared to those treated in non-trauma centers (3, 4). However, transferring all trauma patients to tertiary care centers is impractical and can lead to ED overcrowding, ultimately negatively affecting patient outcomes (5). Given the limitations in resources, selecting the most appropriate hospital for trauma patients presents a significant challenge for prehospital personnel.

In the univariable analysis, GCS and road traffic injury were identified as strong predictors of the need for TTC. These findings are consistent with the World Health Organization's finding that road traffic injury is the eighth leading cause of death across all age groups (16). Numerous prehospital trauma triage guidelines (10, 17) and prediction scores have been developed to assess resource utilization in trauma centers (12, 18), most of which have been conducted in Western countries. Despite variations in settings and populations, this study highlights that the mechanism of injury, oxygen saturation, respiratory rate, and GCS are significant factors in prehospital trauma triage, which is consistent with previous research.

In our study, older age emerged as a protective factor, contrasting with findings from previous research (19, 20). Within Bangkok's metropolitan EMS system, traffic law enforcement plays a role in shaping prehospital response and patient outcomes. Road traffic accidents, typically involving high-impact mechanisms, predominantly affect younger individuals, whereas trauma incidents among older adults are more often associated with low-impact mechanisms, such as falls. Furthermore, trauma patients who received prehospital interventions had a higher likelihood of requiring trauma team activation than those who did not. However, only prognostic variables were included in the final model, as prehospital interventions are treatment-related factors dependent on the provider's level of care.

Despite the statistical significance of prehospital interventions and scene triage, these parameters were not included in the need for TTC prediction model. The concern was that prehospital interventions and triage decisions are often based on the experiences of individual providers, which may not accurately reflect the patient's clinical condition. This study achieved an accuracy of 73%, which, while modest, can be explained by the time gap between the prehospital parameters and in-hospital outcomes. During this interval, changes in patients' clinical conditions may occur, potentially impacting the predictive accuracy of the prognostic model.

Bypassing local hospitals and transporting trauma patients directly to specialized trauma centers is well-established in many developed countries. However, this practice may not be applicable in some settings, especially in developing countries with limited resources. Implementing a simplified clinical prediction model may assist prehospital providers in selecting appropriate destinations for trauma patients. It is recommended that patients identified within the need for TTC high-risk category should be transported directly to a tertiary trauma center. Conversely, individuals classified in the low-risk category may be conveyed to the nearest local hospital. For those categorized as moderate-risk, the decision regarding transport should be made based on the EMS provider's judgment, considering the patient's condition and the proximity to advanced care facilities.

5. Limitations

This study has several limitations. Firstly, it is a single-center study conducted at a super-tertiary trauma facility in Bangkok Metropolitan. Therefore, the study population may not be representative of populations in other settings, particularly in rural areas where 74% of high-risk trauma mechanisms, such as road traffic injury, occur. Additionally, the retrospective design of the study may introduce biases in data collection and patient selection. Further multi-center studies or external validations are needed to confirm and refine the need for TTC prediction model, ensuring its applicability across diverse healthcare settings.

6. Conclusions

This prognostic prediction model, which comprises five predictors, demonstrates high discrimination and calibration in predicting the probability of need for TTC. The model may serve as a tool for EMS providers to triage prehospital trauma patients and select the most appropriate receiving facility.

7. Declarations

7.1. Acknowledgments

None.

7.2. Authors' Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; participated in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

7.3. Ethical considerations

This study was approved by the Committee on Human Rights Related to Research Involving Human Subjects, Faculty of Medicine Ramathibodi Hospital, Mahidol University (COA. NO MURA2023/477). According to the nature of the study, which was a retrospective review of medical records, the institutional review board (IRB) waived the informed consent process. The study complies with a statement covering patient data confidentiality and the Declaration of Helsinki.

7.4. Availability of data and materials

The datasets utilized and/or analyzed throughout the present study may be obtained from the corresponding author upon reasonable request.

7.5. Funding source

No funding was obtained for this study.

7.6. Competing interests

The authors declare that they have no competing interests.

7.7. Using artificial inteligence chatbots

During the preparation of this work, the authors used ChatGPT 4.0 and Grammarly AI in order to check and correct grammatical errors during the manuscript writing process. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

References

1. Haagsma JA, Graetz N, Bolliger I, Naghavi M, Higashi H, Mullany EC, et al. The global burden of injury: incidence, mortality, disability-adjusted life years and time trends from the Global Burden of Disease study 2013. Inj Prev. 2016;22(1):3-18.
2. Xu J, Murphy SL, Kochanek KD, Arias E. Mortality in the United States, 2021. NCHS Data Brief. 2022(456):1-8.
3. Morris RS, Karam BS, Murphy PB, Jenkins P, Milia DJ, Hemmila MR, et al. Field-Triage, Hospital-Triage and Triage-Assessment: A Literature Review of the Current Phases of Adult Trauma Triage. J Trauma Acute Care Surg. 2021;90(6):e138-e45.
4. MacKenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL, et al. A national evaluation of the effect of trauma-center care on mortality. N Engl J Med. 2006;354(4):366-78.
5. Pearce S, Marchand T, Shannon T, Ganshorn H, Lang E. Emergency department crowding: an overview of reviews describing measures causes, and harms. Intern Emerg Med. 2023;18(4):1137-58.
6. Laksanamapune T, Yuksen C, Thiamdao N. Pre-hospital Associated Factors of Survival in Traumatic Out-of-hospital Cardiac Arrests: An 11-Year Retrospective Cohort Study. Archives of Academic Emergency Medicine. 2024;13(1):e15.
7. Pochaisan O, Pattanarattanamolee R, Pongphuttha W, Chadbunchachai W, Nakahara S. Development of an emergency medical services system in Thailand: Roles of the universal health coverage and the national lead agency. Emerg Med Australas. 2021;33(4):756-8.
8. Phungoen P, Cheung LW, Ienghong K, Apiratwarakul K. Characteristics and Outcomes of Patient Transport to the Hospital by Emergency Medical Services (EMS); a Cross-sectional Study. Arch Acad Emerg Med. 2023;11(1):e69.
9. Kong SY, Shin SD, Tanaka H, Kimura A, Song KJ, Shaun GE, et al. Pan-Asian Trauma Outcomes Study (PATOS): Rationale and Methodology of an International and Multicenter Trauma Registry. Prehosp Emerg Care. 2018;22(1):58-83.
10. Sasser SM, Hunt RC, Faul M, Sugerman D, Pearson WS, Dulski T, et al. Guidelines for field triage of injured patients: recommendations of the National Expert Panel on Field Triage, 2011. MMWR Recomm Rep. 2012;61(Rr-1):1-20.
11. Yuksen C, Angkoontassaneeyarat C, Thananupappaisal S, Laksanamapune T, Phontabtim M, Namsanor P. Accuracy of Trauma on Scene Triage Screening Tool (Shock Index, Reverse Shock Index Glasgow Coma Scale and National Early Warning Score) to Predict the Severity of Emergency Department Triage: A Retrospective Cross-Sectional Study. Open Access Emerg Med. 2023;15:79-91.
12. Morris R, Karam BS, Zolfaghari EJ, Chen B, Kirsh T, Tourani R, et al. Need for Emergent Intervention within 6Hours: A Novel Prediction Model for Hospital Trauma Triage. Prehosp Emerg Care. 2022;26(4):556-65.
13. Roden-Foreman JW, Rapier NR, Yelverton L, Foreman ML. Asking a Better Question: Development and Evaluation of the Need For Trauma Intervention (NFTI) Metric as a Novel Indicator of Major Trauma. J Trauma Nurs. 2017;24(3):150-7.
14. Bhaumik S, Hannun M, Dymond C, DeSanto K, Barrett W, Wallis LA, et al. Prehospital triage tools across the world: a scoping review of the published literature. Scand J Trauma Resusc Emerg Med. 2022;30(1):32.
15. Tienpratarn W, Nakpipat N, Yuksen C, Wongwaisayawan

S, Phoothothum Y, Jaiboon S. Clinical Associated Factors of Tile B/C Type of Pelvic Ring Fractures; a Retrospective Cross-sectional study. Arch Acad Emerg Med. 2024;12(1):e49.
16. Organization WH. Global status report on road safety 2018. Geneva, Switzerland: World Health Organization; 2018.
17. Cox S, Currell A, Harriss L, Barger B, Cameron P, Smith K. Evaluation of the Victorian state adult pre-hospital trauma triage criteria. Injury. 2012;43(5):573-81.
18. Kalkwarf KJ, Goodman MD, Press GM, Wade CE, Cotton BA. Prehospital ABC Score Accurately Forecasts Patients Who Will Require Immediate Resource Utilization. South Med J. 2021;114(4):193-8.
19. Sammy I, Lecky F, Sutton A, Leaviss J, O'Cathain A. Factors affecting mortality in older trauma patients-A systematic review and meta-analysis. Injury. 2016;47(6):1170-83.
20. Hashmi A, Ibrahim-Zada I, Rhee P, Aziz H, Fain MJ, Friese RS, et al. Predictors of mortality in geriatric trauma patients: a systematic review and meta-analysis. J Trauma Acute Care Surg. 2014;76(3):894-901.

Table 1: Associated factors of the need for tertiary trauma care among adult multiple trauma patients

Variables	Need for Tertiary Trauma Care		AuROC	95% CI	P-value
	Yes (n=137)	No (n=303)			
Age (years)					
Mean ± SD	53.72 ± 23.04	60.17 ± 23.91	0.594	0.521-0.635	0.008
≥ 65	48 (35.04)	149 (49.17)	0.430	0.380-0.478	0.007
Sex					
Female	46 (33.58)	147(48.51)	0.425	0.377-0.474	0.004
BMI (Kg/m2)					
Mean ± SD	24.04 ±5.80	23.97 ± 5.01	0.526	0.433-0.618	0.933
Comorbidities					
Cardiac	21 (18.26)	53 (21.46)	0.484	0.440-0.528	0.576
Respiratory	11 (9.91)	14 (5.91)	0.520	0.488-0.552	0.187
Cancer	7 (6.31)	17 (7.20)	0.496	0.467-0.524	0.825
Liver	7 (6.31)	4 (1.69)	0.523	0.499-0.547	0.042
Renal	6 (5.45)	27 (11.34)	0.471	0.441-0.500	0.114
Hematology	7 (6.19)	14 (5.86)	0.502	0.475-0.529	1.000
Total	55 (50.00)	152 (65.24)	0.424	0.368-0.480	0.009
Mechanism					
Blunt injury	130 (96.30)	262 (97.40)	0.495	0.476-0.513	0.545
Road traffic injury	70 (51.85)	84 (31.23)	0.603	0.553-0.654	<0.001
Prehospital Vital Signs					
Respiratory rate (/min)	20.99 ± 3.45	19.93 ± 3.90	0.611	0.545-0.677	0.021
Respiratory rate ≥22 /min	35 (33.02)	19 (10.27)	0.614	0.564-0.664	<0.001
Oxygen saturation (%)	94.84 ± 7.27	96.50 ± 6.45	0.576	0.501-0.651	0.049
Oxygen saturation <95%	27 (27.84)	18 (9.73)	0.591	0.541-0.640	<0.001
Systolic BP (mmHg)	136.83 ± 2.75	139.12 ± 2.13	0.443	0.374-0.512	0.069
Systolic BP <90 mmHg	7 (6.80)	4 (2.14)	0.523	0.497-0.550	0.058
MAP <65 mmHg	4 (3.88)	5 (2.67)	0.506	0.484-0.528	0.725
Heart rate (/min)	93.38 ± 21.68	90.59 ± 17.38	0.524	0.453-0.595	0.228
Heart rate >110 /min	23 (21.90)	21 (11.05)	0.554	0.509-0.600	0.016
Glasgow Coma Scale (GCS)					
Mild (13-15)	72 (69.23)	175 (95.11)	0.632	0.625-0.745	<0.001
Moderate (9-12)	14 (13.46)	7 (3.80)			
Severe (3-8)	18 (17.31)	2 (1.09)			
GCS – eyes opening	3.30 ± 0.11	3.93 ± 0.02	0.655	0.606-0.704	<0.001
GCS – verbal response	4.05 ± 0.15	4.83 ± 0.05	0.624	0.574-0.674	<0.001
GCS – motor response	5.34 ± 0.14	5.93 ± 0.03	0.603	0.559-0.647	<0.001
Prehospital Interventions					
Pressure dressing	43 (40.95)	51 (24.52)	0.588	0.532-0.644	0.002
Airway intervention	18 (16.51)	1 (0.45)	0.580	0.545-0.616	<0.001
Oxygen supplementation	51 (46.36)	23 (10.45)	0.680	0.628-0.731	<0.001
Positive pressure ventilation	7 (6.36)	0 (0.00)	0.532	0.509-0.555	<0.001
IV fluid administration	46 (42.20)	18 (8.18)	0.670	0.620-0.720	<0.001
Aggressive fluid	18 (16.82)	3 (1.37)	0.577	0.541-0.614	<0.001
Extremity immobilization	23 (21.30)	28 (12.73)	0.543	0.498-0.587	0.052
Pelvic immobilization	5 (4.63)	4 (1.82)	0.514	0.492-0.536	0.162
Spinal immobilization	72 (63.72)	58 (26.24)	0.687	0.634-0.741	<0.001
Scene Triage					
Emergent	58 (65.91)	25 (19.38)	0.751	0.688-0.814	<0.001
Urgent	19 (21.59)	52 (40.31)			
Non-urgent	11 (12.50)	52 (40.31)			

BMI: body mass index; min: minute; BP: blood pressure; MAP: mean arterial pressure; mmHg: millimeter of Mercury; IV: intravenous; AuROC: area under the receiver operating characteristic curve; CI: confidence interval.

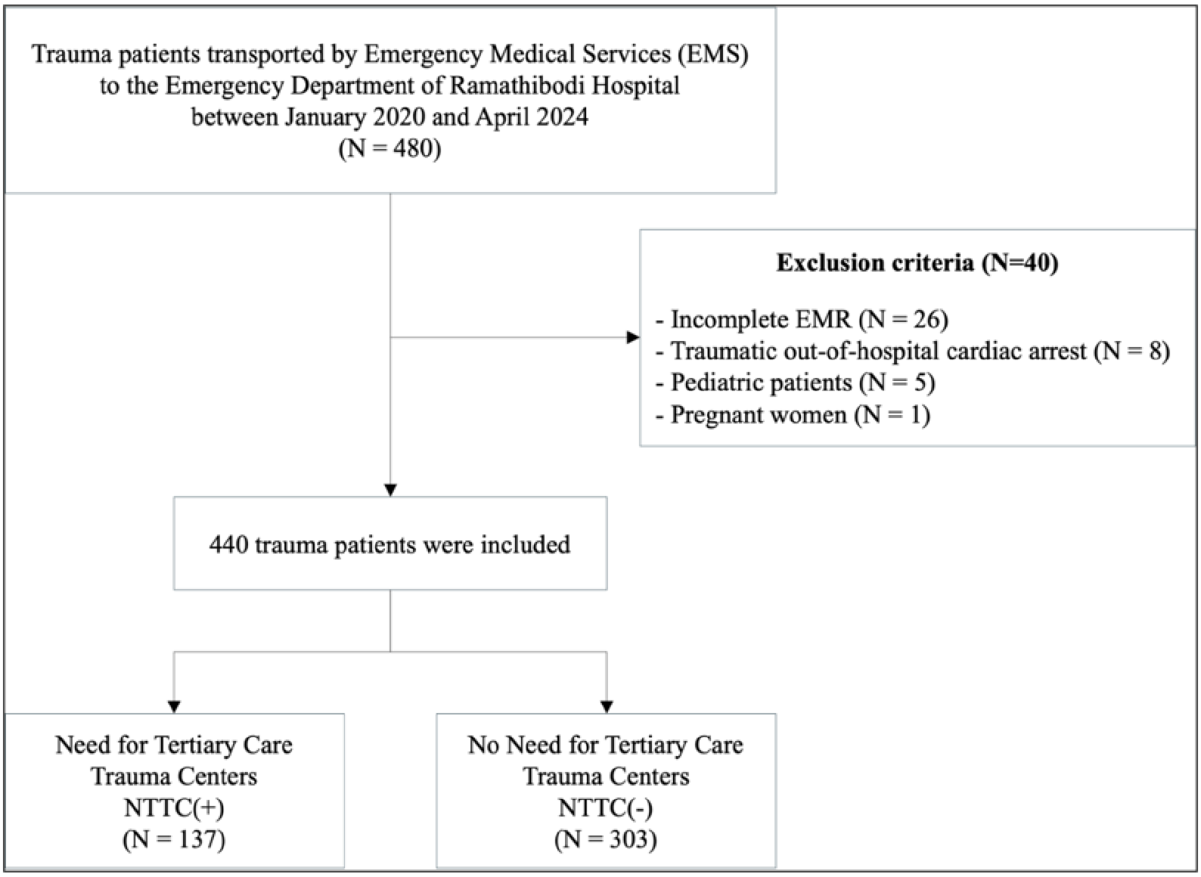

Figure 1: Study flow diagram. EMR: Electronic Medical Record.

Table 2: Multivariable logistic regression analysis of clinical prognostic factors for the need for tertiary trauma care

Variables	Coefficient	95% CI	aOR (95% CI)	P-value
Age	-0.003	-0.018 to 0.012	0.99 (0.98 - 1.01)	0.693
Traffic mechanism	0.848	0.150 to 1.546	2.34 (1.16 - 4.69)	0.017
Respiratory rate	0.044	-0.037 to 0.124	1.04 (0.96 - 1.13)	0.285
Heart rate	-0.004	-0.020 to 0.012	0.99 (0.98 - 1.01)	0.610
Glasgow Coma Scale	-0.312	-0.451 to -0.173	0.73 (0.64 - 9.84)	<0.001
Constant	3.135	-0.164 to 6.434		0.062

CI: confidence interval; aOR: adjusted odds ratio.

Table 3: Predictive performance of the prognostic model for the need for tertiary trauma care

Probability	Need for Tertiary Trauma Care		LHR+	P-value
	Yes (n=99)	No (n=170)		
Low (<0.25)	27 (27.27)	101 (59.41)	0.46(0.33-0.65)	<0.001
Moderate (0.25-0.65)	46 (46.46)	66 (38.82)	1.20(0.90 - 1.59)	0.249
High (>0.65)	26 (26.26)	3 (1.76)	14.88(4.62-47.91)	<0.001

LHR: likelihood ratio.

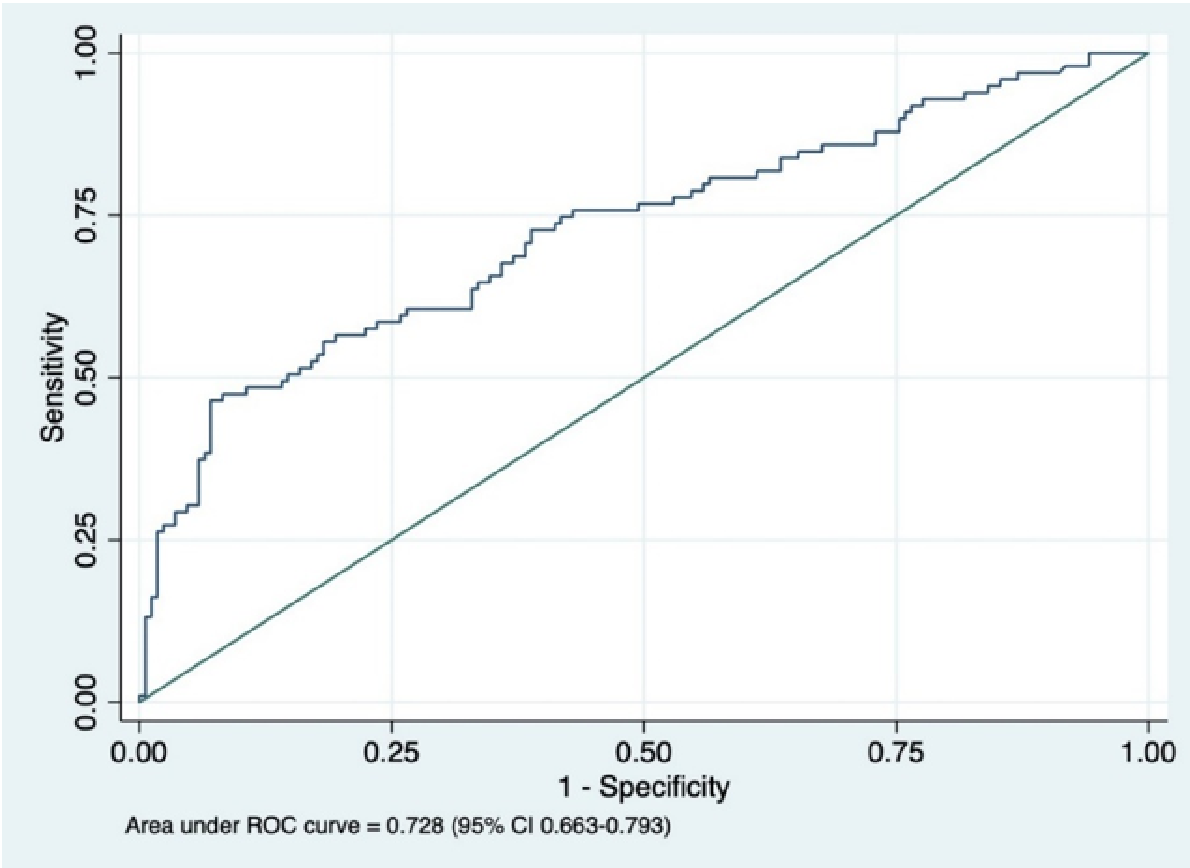

Figure 2: Area under the receiver operating characteristic curve (AuROC) of the prediction model of the need for tertiary trauma care. CI: confidence interval.

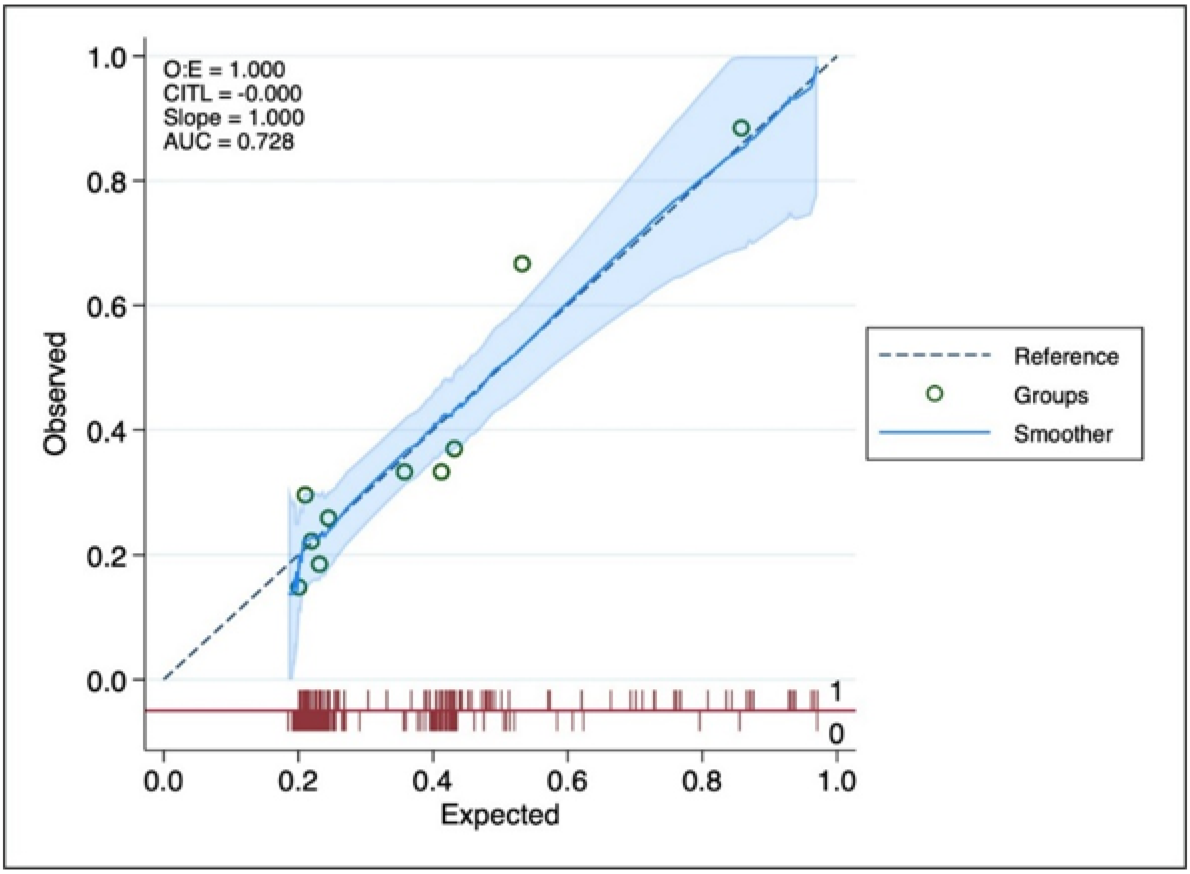

Figure 3: Calibration plot of the prediction model of the need for tertiary trauma care. AUC: area under the curve; CITL: calibration in the large; O:E: observed: expected.

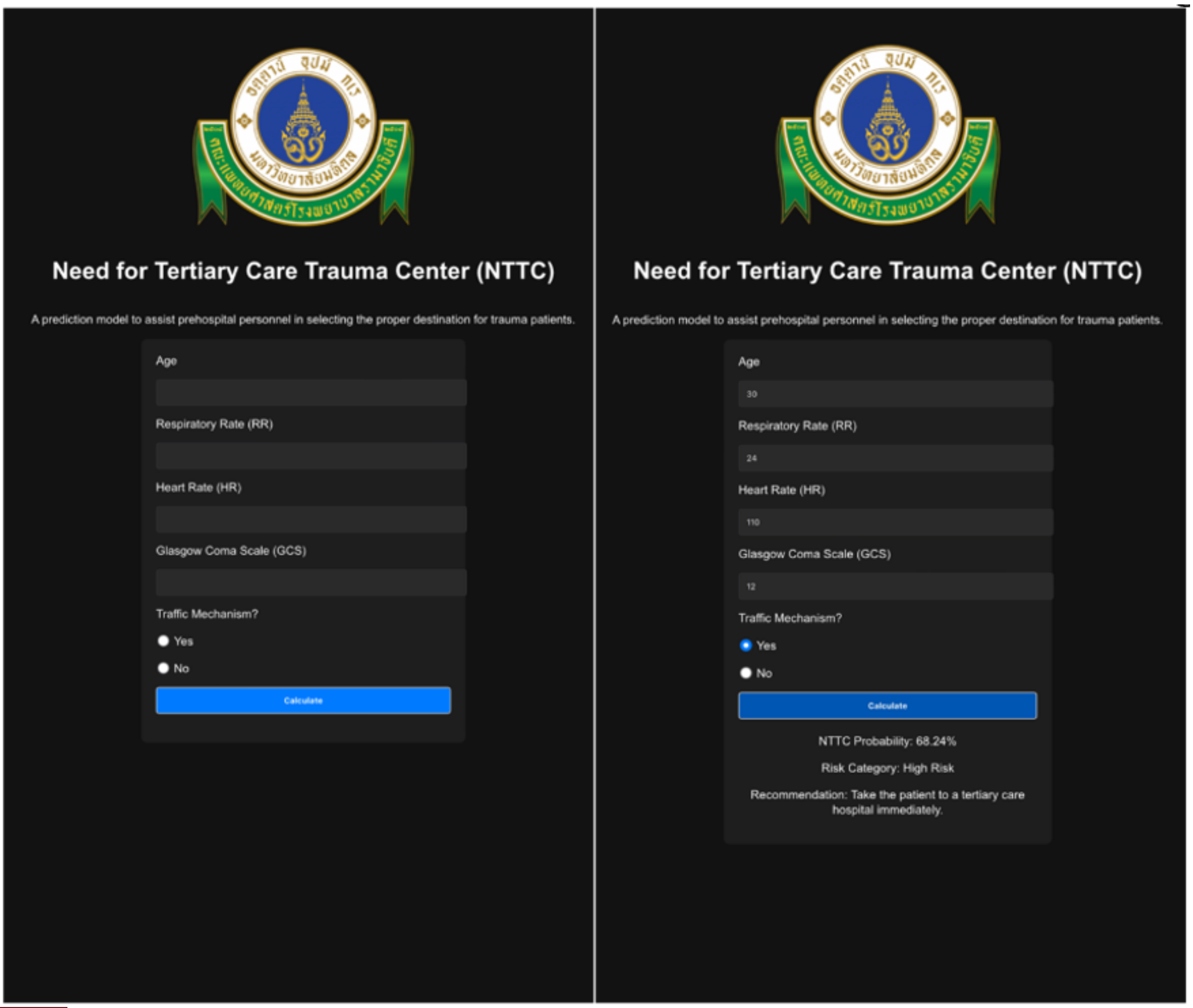

Figure 4: Display of web-based calculator of model for predicting the need for tertiary trauma care.