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Comparison of the Canadian Triage and Acuity Scale and Emergency Severity Index for Predicting Clinical Outcomes in Emergency Department Patients: A Prospective Cohort Study

Chanikarn Mapairoje, and Parinya Tianwibool

Department of Emergency Medicine, Faculty of Medicine, Chiang Mai University. Thailand

Correspondence:
Parinya Tianwibool , MD, Department of Emergency Medicine, Faculty of Medicine, Chiang Mai University, 110 Inthawaroroj Rd., Sriphoom Subdistrict, Muang District, Chiang Mai, 50200, Thailand.
E-mail: parinya.t@cmu.ac.th

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ABSTRACT

OBJECTIVE This study aimed to assess the accuracy of CTAS and ESI and examine their correlations with hospitalization rates, 24-hour mortality, and resource utilization.

METHODS: A prospective cohort study collected CTAS and ESI data from patients at the Maharaj Nakorn Chiang Mai Hospital Emergency Department (ED) between January and June 2018.

RESULTS: A total of 413 patients were included. Higher triage severity was associated with increased hospitalization rates and higher 24-hour mortality ($p < 0.05$). Resource utilization in the ED also tended to be higher for patients with more severe triage levels ($p < 0.05$), with the exception of specific procedures such as defibrillation, external pacing, intramuscular drug administration, and complex procedures. There was good statistical agreement between CTAS and ESI triage levels (weighted kappa = 0.67).

CONCLUSION: Both CTAS and ESI levels correlate with hospitalization rates and 24-hour mortality. Resource utilization in the ED increases with higher triage severity levels. The good agreement between CTAS and ESI triage levels suggests that the two systems perform comparably in emergency severity assessments.

KEYWORDS accuracy, Canadian Triage and Acuity Scale , Emergency Severity Index , hospitalization rates, 24-hour mortality rate, resource utilization, emergency department

INTRODUCTION

Emergency Medicine is a branch of medicine encompassing emergency operations, education, training, and research on patient management in emergency conditions (1). One of the critical components of emergency management is the triage system. Accurate and efficient triage is essential in managing patients' medical conditions and allocating available but limited resources so patients with more severe conditions can be given priority in management (2, 3).

Currently, there are many triage systems in use, such as 3-level and 5-level triage systems. Studies have shown that 5-level triage systems are more accurate than 3-level triage systems3. An example of the more widely used 5-level triage is the Canadian Triage and Acuity Scale (CTAS). A characteristic of CTAS is the use of signs or symptoms of patients, in conjunction with vital signs, to enable designation of patients in one of five emergency levels. Each triage level has different time frames regarding physician contact which are prioritized by severity. Pain score is

also used as a criterion in CTAS. CTAS, which involves repeated assessments and evaluations, has also been adapted for use in pediatrics (2, 4). Additionally, CTAS has been shown to correlate with resource use in patient care.

Another triage system widely used in Thailand is the Emergency Severity Index (ESI). Currently, the fourth version is in use following the 2016 announcement by the National Institute for Emergency Medicine recommending its use (5, 6). ESI enables the triage of patients according to the severity of their condition and the resources needed for their care. A score in a higher emergency level suggests greater urgency and higher expected resource use in comparison to patients receiving a lower score. However, ESI does not have a definite time frame for physician contact (1, 5, 6). A study conducted in North America revealed no differences between CTAS and ESI in predicting resource use and the result of care of patients in the acute care setting (7).

Maharaj Nakorn Chiang Mai Hospital designates CTAS as its triage tool. A study revealed a statistically significant correlation between CTAS triage level and 24-hour mortality rate, ICU admission rate, and number of interventions performed on the patient, suggesting higher efficiency of CTAS in triaging patients in the Emergency Department (ED) (8, 9). Nonetheless, another study found that most hospitals in Thailand use the ESI system6, as it is easier to utilize to evaluate symptoms as well as resource use compared to CTAS, which requires signs, symptoms, and vital signs. Computer programs frequently help in confirming CTAS triage (10). No prior study in Thailand has compared the accuracy of triage and the ability to predict patient outcomes between CTAS and ESI. In this study, twenty-four-hour mortality was chosen as the variable for analysis as it reflects early clinical deterioration and immediate Emergency Department Care following triage. Longer-term outcomes, such as 72-hour or in-hospital mortality, may be confounded by inpatient management and hospital-related complications. The primary objective of this study was to compare the predictive validity of CTAS and ESI for hospitalization, 24-hour mortality, and ED resource utilization. The secondary objective was to evaluate the level of agreement between CTAS and ESI triage levels.

METHODS

Study design and setting

This prospective cohort study was conducted in the Emergency Department of Maharaj Nakorn Chiang Mai Hospital in 2018. The study coincided with a formal triage training program for paramedics and emergency nurse practitioners, during which both the Canadian Triage and Acuity Scale (CTAS) and the Emergency Severity Index (ESI) were implemented concurrently. Although recruitment was initially planned from January to June 2018, enrollment was completed within the first two months after the predefined enrollment target had been achieved.

Eligible patients presenting to the emergency department were consecutively recruited during the enrollment period. Written informed consent was obtained from patients capable of providing consent or from their legally authorized representatives, as appropriate. Patients for whom informed consent could not be obtained were not enrolled.

Each enrolled patient underwent prospective triage assessments using both CTAS and ESI by two independent trained triage personnel, including registered nurses or paramedics. Each assessor used only their assigned triage system and was blinded to the assessment made by the other assessor. Triage findings were documented separately using standardized forms (Appendix 1), and the results were not shared between assessors during patient evaluation.

All triage personnel had received formal training in both CTAS and ESI and had passed the emergency department triage competency examination. The study procedures did not interfere with routine clinical management, and standard patient care was maintained throughout. Triage assessments were conducted across all three hospital shifts.

Following completion of clinical care, an independent data collector reviewed hospital medical records to obtain information on life-saving interventions, emergency department resource utilization, hospitalization, and 24-hour mortality using a standardized data collection form (Appendix 2). Thus, patient enrollment and triage assessments were conducted prospectively, while clinical outcomes were subsequently ascertained through hospital medical record review.

Patients with incomplete outcome data were excluded from the final analysis. The potential for selection bias arising from these exclusions was considered when interpreting the findings.

Ethical considerations

This study was approved by the Research Ethics Committee, Faculty of Medicine, Chiang Mai University (Approval No. EME-2560-05043, approved; November 24, 2017).

Study population

Patients presenting to the emergency department during the recruitment period were consecutively enrolled after obtaining written informed consent from patients or their legally authorized representatives. Patients for whom consent could not be obtained were not enrolled. Those with incomplete outcome data were excluded from the final analysis.

Data collection

The study team collected data from the hospital records, including gender, age, underlying disease, chief complaint, vital signs, triage level, life-saving interventions, resource utilization for the patient and patient outcomes.

Outcome measures and definition of accuracy

In this study, accuracy was defined as the predictive validity of CTAS and ESI triage levels in relation to clinically meaningful outcomes. Outcomes included hospitalization rates, 24-hour mortality, life-saving interventions, and ED resource utilization. The associations between triage level and outcomes were analyzed to assess triage performance.

Statistical analysis

The calculation of the sample size was based on a study by Worster et al. (7), using correlations between different triage levels of CTAS and in-hospital mortality. The resulting sample size was 408 patients. However, 7-9% of patients in the Worster et al. study were found to have incomplete data. For that reason, the present study aimed to collect 20% more than the calculated sample size, aiming for a total of 490 patients. Descriptive statistics were used to analyze the sample population characteristics. Findings are shown as mean, percentage, median, and interquartile range with standard deviation according to data distribution. The level of agreement between CTAS and ESI was analyzed using weighted Cohen's Kappa. Correlations between emergency level and resource use, life-saving intervention, hospitalization, and 24-hour mortality rate were analyzed using either Spearman's rank correlation, Chi-square test, or Fisher's exact test. A p-value < 0.05 was considered statistically significant. Statistical analysis was performed using SPSS® version 23.

RESULTS

A total of 529 patients were prospectively enrolled during the two-month recruitment period in 2018 and underwent independent triage assessments using both CTAS and ESI. Of these, 116

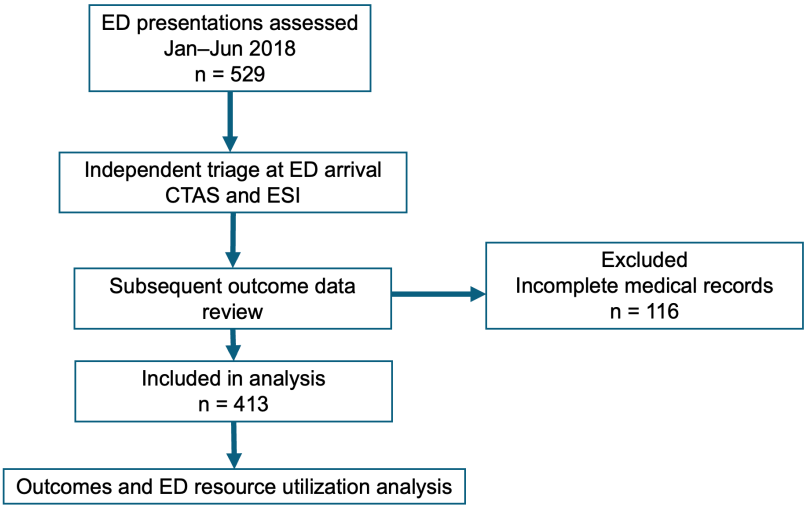


Figure 1. Study flow diagram

patients (21.9%) were excluded due to incomplete outcome data, leaving 413 patients (78.1%) for the final analysis (Figure 1). Among the analyzed patients, 224 (54.2%) were female and 189 (45.8%) were male. The median age was 40 years, ranging from 6 months to 98 years.

The most common underlying medical condition was hypertension (25 patients, 6.1%), followed by cardiac disease (18 patients, 4.4%), diabetes mellitus (11 patients, 2.7%), chronic obstructive pulmonary disease (10 patients, 2.4%), and other conditions such as lung cancer, previous stroke, asthma, and chronic kidney disease (87 patients, 21.1%). A total of 200 trauma cases (48.4%) presented at the ED. Of those, 78 patients (39.0%) had abrasions or lacerations, 53 (26.5%) presented with pain in the extremities, and 22 (11%) presented with head injury. Other trauma presentations included costal pain, ear pain, eye pain, and bruising. A total of 213 non-trauma cases (51.6%) presented at the ED: 30 patients (14.1%) presented with dyspnea, 25 (11.7%) presented with abdominal pain, 23 (10.8%) presented with chest pain and 22 (10.3%) presented with fever. Other non-trauma presentations included limb weakness, palpitation, dizziness, alteration of consciousness, rash, vomiting, and diarrhea. All data are shown in Table 1.

Using CTAS, 24 patients (5.8%) were triaged as level I, 69 (16.7%) as level II, 137 (33.2%) as level III, 157 (38.0%) as level IV, and 26 (6.3%) as level V. Using ESI, 31 patients (7.5%) were triaged as level I, 98 (23.7%) as level II, 142 (34.4%) as level III, 90 (21.8%) as level IV, and 52 (12.6%) as level V. There was a strong agreement between the results from ESI and CTAS, according to the kappa, with a weighting of 0.667.

Higher-level triage using CTAS was found to show a correlation with higher hospitalization rates ($p = 0.000$). A total of 123 patients were hospitalized, with a breakdown by triage level of 19 patients from level I triage (79.2% of level I triage patients), 42 patients from level II triage (60.9% of level II triage patients), 50 patients from level III triage (36.5% of level III triage patients), 11 patients from level IV triage (7.0% of level IV triage patients), and one patient from level V triage (3.8% of level V triage patients). ESI triage had the following number of patients hospitalized stratified by triage level: 23 patients from level I triage (74.2% of level I triage patients), 57 patients from level II triage (58.2% of level II triage patients), 38 patients from level III triage (26.8% of level III triage patients), five patients from level IV triage (5.6% of level IV triage patients), and zero patients from level V triage. These data are shown in Table 2.

A higher level of CTAS triage was statistically significantly associated with higher rates of 24-hour mortality ($p = 0.000$). 24-hour mortality rates for CTAS triage levels are as follows: a total of three patients (0.7%) for all levels with two pa-

Table 1. Patient demographics

Patient characteristics (n = 413)	Total (n = 413)
Gender, n (%)	
Female	224 (54.2)
Male	189 (45.8)
Age (years): median (IQR)	40 (22,64)
Underlying disease, n (%)	
No underlying disease	262 (63.40)
Hypertension	25 (6.1)
Heart disease	18 (4.4)
Diabetes mellitus	11 (2.7)
Chronic obstructive pulmonary disease	10 (2.4)
Others*	87 (21.1)
Chief complaints, n (%)	
Traumatic patients	200 (48.4)
Abrasion/ laceration	78 (39)
Pain on extremities	53 (26.5)
Head injury	22 (11)
Others**	47 (23.5)
Non-traumatic patients	213 (51.6)
Dyspnea	30 (14.1)
Abdominal pain	25 (11.7)
Chest pain	23 (10.8)
Fever	22 (10.3)
Others***	113 (53.1)
Vital signs at triage	
SBP (mmHg): median (IQR)	131 (115,151)
HR (bpm): median (IQR)	90 (77,106)
RR (/min): median (IQR)	18 (18,20)
SpO_2 (%): median (IQR)	98 (96,99)
BT (°C): median (IQR)	36.7 (36.5,37.2)

*Other diseases, e.g., lung cancer, dyslipidemia, cerebrovascular disease, asthma, chronic kidney disease, other cancers; **Other injuries, e.g., costal margin pain, otalgia, ocular pain, contusion; ***Other illnesses, e.g., weakness, palpitations, dizziness, alteration of consciousness, rash, vomiting, diarrhea

SBP, systolic blood pressure; HR, heart rate; RR, respiratory rate; SpO_2, peripheral oxygen saturation; BT, body temperature, IQR, interquartile range

Table 2. Hospitalization and 24-hour mortality rate in each emergency level of CTAS and ESI

Triage system	Emergency level, n (%)					n (%)	Correlation[a]	*p*-value[b]
	Level I	Level II	Level III	Level IV	Level V			
CTAS								
No. of patients	24 (5.8)	69 (16.7)	137 (33.2)	157 (38)	26 (6.3)	413 (100.0)		
Rate of hospitalization	19 (79.2)	42 (60.9)	50 (36.5)	11 (7)	1 (3.8)	123 (29.8)	-0.507	0.000
24-hour mortality	2 (8.3)	1 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.7)	-0.135	0.000
ESI								
No. of patients	31 (7.5)	98 (23.7)	142 (34.4)	90 (21.8)	52 (12.6)	413 (100.0)		
Rate of hospitalization	23 (74.2)	57 (58.2)	38 (26.8)	5 (5.6)	0 (0.0)	123 (29.8)	-0.520	0.000
24-hour mortality	3 (9.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.7)	-0.142	0.000

[a]Spearman's rank correlation; [b]Fisher's exact test, $p < 0.05$; CTAS, Canadian Emergency Department Triage and Acuity Scale, ESI, Emergency Severity Index

Table 3. Life-saving intervention rates and resource use in each level of CTAS triage

CTAS	Emergency level, n (%)					n (%)	Correlation[a]	*p*-value[b]
	Level I	Level II	Level III	Level IV	Level V			
No. of patients	24 (5.8)	69 (16.7)	137 (33.2)	157 (38)	26 (6.3)	413 (100.0)		
Life-saving intervention[c]								
A	8 (33.3)	4 (5.8)	1 (0.7)	0 (0.0)	0 (0.0)	13 (3.1)	-0.268	0.000
B	1 (4.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.2)	-0.085	0.058
C	7 (29.2)	11 (15.9)	14 (10.2)	2 (1.3)	0 (0.0)	34 (8.2)	-0.266	0.000
D	5 (20.8)	1 (1.4)	4 (2.9)	0 (0.0)	0 (0.0)	10 (2.4)	-0.181	0.000
E	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		
Resources utilization[d]								
Laboratory investigation	24 (100.0)	51 (73.9)	85 (62)	14 (8.9)	1 (3.8)	175 (42.4)	-0.623	0.000
Electrocardiogram	11 (45.8)	26 (37.7)	46 (33.6)	6 (3.8)	0 (0.0)	89 (21.5)	-0.387	0.000
Basic imaging	19 (79.2)	45 (65.2)	71 (51.8)	44 (28)	2 (7.7)	181 (43.8)	-0.374	0.000
Other radiographic studies	17 (70.8)	41 (59.4)	50 (36.5)	13 (8.3)	0 (0.0)	121 (29.3)	-0.483	0.000
Intravenous fluid	14 (58.3)	32 (46.4)	39 (28.5)	4 (2.5)	0 (0.0)	89 (21.5)	-0.458	0.000
Intravenous medication	19 (79.2)	42 (60.9)	57 (41.6)	16 (10.2)	1 (3.8)	135 (32.7)	-0.485	0.000
Intramuscular medication	0 (0.0)	3 (4.3)	2 (1.5)	3 (1.9)	0 (0.0)	8 (1.9)	-0.035	0.642
Nebulization	2 (8.3)	4 (5.8)	7 (5.1)	0 (0.0)	0 (0.0)	13 (3.1)	-0.159	0.005
Special consultation	23 (95.8)	48 (69.6)	57 (41.6)	21 (13.4)	2 (7.7)	151 (36.6)	-0.515	0.000
Simple procedure	5 (20.8)	10 (14.5)	22 (16.1)	34 (21.7)	1 (3.8)	72 (17.4)	0.012	0.178
Complex procedure (conscious sedation)	0 (0.0)	1 (1.4)	1 (0.7)	1 (0.6)	0 (0.0)	3 (0.7)	-0.023	0.856

[a]Spearman's rank correlation; [b]Fisher's exact test, $p < 0.05$; [c]life-saving intervention; CTAS, Canadian Emergency Department Triage and Acuity Scale, A, airway/ breathing e.g. intubation, BiPAP; B, electrical therapy e.g. defibrillation, cardioversion, external pacing; C, IV resuscitation or blood administration; D, emergency medications e.g. atropine, dopamine, adenosine, adrenaline, 50% glucose; E: Procedures, e.g., Needle decompression, pericardiocentesis, open thoracotomy, intraosseous acces; [d]Resources utilization

- Laboratory investigation e.g. blood/ urine examination
- Basic imaging e.g. chest x-ray, plain abdomen, KUB
- Other radiographic studies e.g. CT, ultrasound, MRI
- Simple procedure e.g. laceration repair, foley catheterization

tients in triage level I (8.3% of level I patients) and one patient in triage level II (1.4% of level II patients). Similarly, a higher level of ESI triage was statistically significantly associated with higher 24-hour mortality rates ($p = 0.000$). All patient mortalities were level I (3 patients, 9.7% of all level I patients). A zero-mortality rate was found for ESI triage levels II, III, IV, and V, as shown in Table 2.

Life-saving interventions were found to be associated with higher levels of triage in both the CTAS and ESI systems ($p = 0.000$). In CTAS, airway and breathing management was found to have the highest correlation with triage level (Spearman's rank correlation $r_s = -0.268$), with eight patients (33.3% of triage level I patients), followed by fluid resuscitation ($r_s = -0.266$) with the highest number

Table 4. Life-saving intervention rates and resource use in each level of ESI triage

ESI	Emergency level, n (%)					n (%)	Correlation[a]	*p*-value[b]
	Level I	Level II	Level III	Level IV	Level V			
No. of patients	31 (7.5)	98 (23.7)	142 (34.4)	90 (21.8)	52 (12.6)	413 (100)		
Life-saving intervention[c]								
A	8 (25.8)	3 (3.1)	2 (1.4)	0 (0.0)	0 (0.0)	13 (3.1)	-0.231	0.000
B	1 (3.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.2)	-0.082	0.075
C	12 (38.7)	13 (13.3)	9 (6.3)	0 (0.0)	0 (0.0)	34 (8.2)	-0.306	0.000
D	6 (19.4)	1 (1.0)	3 (2.1)	0 (0.0)	0 (0.0)	10 (2.4)	-0.177	0.000
E	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		
Resource utilization[d]								
Laboratory investigation	29 (93.5)	73 (74.5)	67 (47.2)	6 (6.7)	0 (0.0)	175 (42.4)	-0.619	0.000
Electrocardiogram	11 (35.5)	45 (45.9)	28 (19.7)	5 (5.6)	0 (0.0)	89 (21.5)	-0.380	0.000
Basic Imaging	23 (74.2)	61 (62.2)	70 (49.3)	23 (25.6)	4 (7.7)	181 (43.8)	-0.395	0.000
Other radiographic studies	22 (71)	54 (55.1)	37 (26.1)	7 (7.8)	1 (1.9)	121 (29.3)	-0.477	0.000
Intravenous fluid	18 (58.1)	41 (41.8)	29 (20.4)	1 (1.1)	0 (0.0)	89 (21.5)	-0.445	0.000
Intravenous medication	22 (71)	56 (57.1)	49 (34.5)	8 (8.9)	0 (0.0)	135 (32.7)	-0.481	0.000
Intramuscular medication	0 (0.0)	3 (3.1)	3 (2.1)	2 (2.2)	0 (0.0)	8 (1.9)	-0.027	0.830
Nebulization	2 (6.5)	7 (7.1)	4 (2.8)	0 (0.0)	0 (0.0)	13 (3.1)	-0.156	0.018
Special consultation	29 (93.5)	58 (59.2)	58 (40.8)	6 (6.7)	0 (0.0)	151 (36.6)	-0.550	0.000
Simple procedure	9 (29.0)	8 (8.2)	30 (21.1)	22 (24.4)	3 (5.8)	72 (17.4)	0.001	0.001
Complex procedure (conscious sedation)	0 (0.0)	0 (0.0)	3 (2.1)	0 (0.0)	0 (0.0)	3 (0.7)	-0.005	0.461

[a]Spearman's rank correlation; [b]Fisher's exact test, $p < 0.05$; [c]Life-saving intervention

A, airway/ breathing e.g. intubation, BiPAP; B, electrical therapy e.g. defibrillation, cardioversion, external pacing; C, IV resuscitation or blood administration; D, emergency medications e.g. atropine, dopamine, adenosine, adrenaline, 50% glucose; E, procedures e.g. Needle decompression, pericardiocentesis, open thoracotomy, intraosseous access

[d]Resources utilization

- Laboratory investigation e.g. blood/ urine examination
- Basic imaging e.g. chest x-ray, plain abdomen, KUB
- Other radiographic studies e.g. CT, ultrasound, MRI
- Simple procedure e.g. laceration repair, foley catheterization

of patients (34 patients, 8.2%). Electrical therapy, such as defibrillation or external pacing, was used with 1 patient, triaged as level I, with $r_s = -0.085$ ($p = 0.058$). In terms of ESI, the intervention with the highest correlation with triage level was fluid resuscitation ($r_s = -0.306$), followed by airway and breathing management ($r_s = -0.231$), and emergency medication administration ($r_s = -0.177$), as shown in Tables 3 and 4.

The correlation between triage levels and resource utilization—including laboratory investigations, electrocardiography, imaging, intravenous fluid resuscitation, intravenous medication, nebulized medication, and specialist consultation—was significantly higher among patients assigned to more urgent triage levels in both the CTAS and ESI systems ($p < 0.05$). This trend reflects the expected increase in clinical complexity among higher-acuity patients. However, certain interventions, e.g., electrical therapies (defibrillation and external pacing), intramuscular medication administration, and complex procedures, did not demonstrate statistically significant correlation with higher triage levels, likely due to their low

Table 5. Agreement between CTAS and ESI triage levels with life-saving interventions and hospitalization

Inter-rater reliability	Agreement	Strength of agreement
Intubation	0.750	good
Intravenous fluid resuscitation	0.600	good
Emergent medication administration	0.792	good
Rate of hospitalization	0.596	moderate
Accuracy of CTAS and ESI	0.667	good

[e]Weighted kappa use to find the agreement [*strength]

CTAS, Canadian Emergency Department Triage and Acuity Scale, ESI, Emergency Severity Index

frequency in the study population. Simple procedures showed only minimal correlation with triage urgency (r_s = 0.001, p = 0.001). These findings are summarized in Tables 3 and 4.

Inter-rater reliability in evaluating certain interventions and hospitalization rates using weighted kappa statistics found that airway and breathing management, fluid resuscitation, and emergent medication administration showed good agreement with triage level (kappa weighting = 0.750, 0.6, and 0.792, respectively), and hospitalization rates were found to have moderate agreement with kappa weighting (0.596), as shown in Table 5.

DISCUSSION

This study found that both CTAS and ESI triage systems demonstrated comparable predictive validity in stratifying patient acuity, with higher triage levels associated with increased rates of hospitalization, 24-hour mortality, life-saving interventions, and ED resource utilization. These findings indicate that patients classified as more urgent were more likely to require intensive care and interventions. In addition, good agreement was observed between CTAS and ESI triage levels, supporting the consistency of classification of patient acuity across the two systems.

Higher-acuity patients inherently require more diagnostic evaluation, monitoring, and timely therapeutic interventions, which explains the greater overall resource utilization observed in higher triage levels. In contrast, procedures such as defibrillation, external pacing, intramuscular drug administration, and complex procedures did not correlate with triage severity because they occurred infrequently and are typically performed in specific clinical situations rather than reflecting global resource needs. These interventions are event-driven rather than resource-intensive, which limits their association with overall triage acuity. Our findings are in partial contrast to Worster et al., which reported only a moderate correlation between triage acuity and ED resource utilization, and found no statistically significant difference between ESI and CTAS in their ability to predict resource use or immediate outcomes (7). These differences may be due to variations in patient populations, study settings, and the operational definitions of "resource utilization."

Regarding ESI, our results are consistent with Tanabe and colleagues who found that ESI scores could predict overall ED resource consumption and also examined the use of length of stay to support inpatient care planning (11). The current study reinforces that both CTAS and ESI have predictive value for resource utilization, but that this relationship is procedure-specific and not uniformly strong across all interventions. From an operational perspective, recognizing these utilization patterns may help optimize resource allocation, staffing, and preparedness for high-acuity cases, while acknowledging that certain critical interventions may occur outside the most urgent triage categories.

Life-saving interventions were found to correlate strongly with higher triage levels. However, a small proportion of patients triaged as lower acuity (CTAS or ESI level III or IV) also received life-saving interventions. This finding likely reflects the dynamic nature of Emergency Department Care, as triage represents an initial snapshot assessment and may not capture subsequent clinical deterioration. In addition, certain interventions, such as fluid resuscitation or airway support, may be initiated as precautionary or protocol-driven measures based on evolving clinical judgment rather than initial triage level alone. Lee, et al. found that CTAS triage levels I and II were associated with higher life-saving intervention rates (9); however, that study was conducted in patients aged over 65 years. Our study found similar results to those published by Saisingthong and colleagues in terms of life-saving intervention, hospitalization, and 24-hour mortality; however, Saisingthong et al. only examined patients admitted to the intensive care unit (8). On the other hand, with regard to the ESI system, our study results differed from a study by Platss-Mills et al. which was conducted only in patients older than 65 years (12). In that study, life-saving interventions in the elderly accounted for less than half of all patients in triage level I. This indicates that emphasis should be put on accurate triaging of the elderly as well.

The rationale for comparing CTAS and ESI lies in their concurrent use in ED despite their differing conceptual frameworks. CTAS is primarily physiology- and symptom-based with defined time-to-physician targets, whereas ESI incorporates anticipated resource utilization into triage

decision-making. In this study, the good agreement between CTAS and ESI (weighted Kappa = 0.67), along with their similar associations with hospitalization, 24-hour mortality, and resource utilization, suggests that both systems provide comparable assessments of emergency severity.

From an operational standpoint, ESI may be easier to implement due to its simpler structure and emphasis on resource prediction, making it more user-friendly in high-volume or resource-limited settings. In contrast, CTAS requires more detailed clinical assessment but provides explicit time-based prioritization, which may support patient flow and safety in well-resourced departments. Therefore, while CTAS and ESI show comparable predictive validity, system selection should be guided by local workflow, staffing, and training considerations rather than outcome prediction alone.

Although the data in this study were collected several years ago, the fundamental structure and clinical principles of both CTAS and ESI have remained unchanged. Moreover, the study outcomes—hospitalization, short-term mortality, and ED resource utilization—continue to be clinically relevant. These findings, therefore, remain applicable to current ED practice, particularly in similar training-focused and resource-limited settings.

Limitations

This study has several limitations. First, it was conducted at a single tertiary-care center, Maharaj Nakorn Chiang Mai Hospital, which may limit the generalizability of the findings to other ED settings. Results may differ in institutions with different patient populations, triage practices, or resource availability. Second, patients for whom informed consent could not be obtained were not enrolled, potentially leading to the underrepresentation of critically ill or unconscious patients. Additionally, 116 of 529 enrolled patients (21.9%) were excluded due to incomplete outcome data. Although the final sample exceeded the minimum required sample size, these exclusions may have introduced selection bias. Lastly, the data were collected in 2018, which may limit temporal generalizability. However, the core structure and clinical principles of both the CTAS and the ESI have remained fundamentally unchanged, and the primary outcomes examined remain relevant to contemporary ED practice.

CONCLUSIONS

Both CTAS and ESI triage levels were found to be associated with hospitalization and 24-hour mortality, where patients scoring higher triage levels had higher rates of hospitalization, 24-hour mortality, lifesaving interventions, and resource use. Additionally, good agreement was observed between the ESI and CTAS triage systems.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

C.M.: conceptualization, methodology, data curation, formal analysis, investigation, methodology, validation, visualization, writing — original draft; P.T.: conceptualization, project administration, methodology, formal analysis, project administration, supervision, validation, writing —review and editing.

INSTITUTIONAL REVIEW BOARD STATEMENT

The study was approved by the Research Ethics Committee, Faculty of Medicine, Chiang Mai-University (Approval No. EME-2560-05043; approved November 24, 2017

INFORMED CONSENT STATEMENT

Written informed consent was obtained from all enrolled patients or their legally authorized representatives, as appropriate, before study participation. Patients who were unable to provide informed consent and for whom consent from a legally authorized representative could not be obtained were not enrolled in the study.

SUPPLEMENTARY MATERIALS

The following supporting information can be downloaded at: Supplementary file

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Supplementary 1

Data record form

No. .....
Gender .....Age .....
Chief complaint .....
Triage time ..... Physician contact time .....

Vital signs

BT	BP	PR .....
RR	O_2sat	Pain score .....

Underlying disease/ Past illness .....
Mechanism of injury ..... Bleeding control .....
ESI triage level ..... CTAS triage level .....

Supplementary 2

Life-saving intervention and resource utilization record form

Life-saving intervention

- Airway/breathing □ Intubation □ Surgical airway □ BiPAP
- Electrical therapy pacing □ Defibrillation □ Cardioversion □ External
- Procedures □ Needle decompression □ Pericardiocentesis
  □ Open thoracotomy □ Intraosseous access
- Hemodynamics □ IV resuscitation .....
  □ Blood administration .....
- Control of major bleeding .....
- Medications □ Naloxone □ 50% glucose □ Dopamine
  □ Atropine □ Adenosine □ Other.....

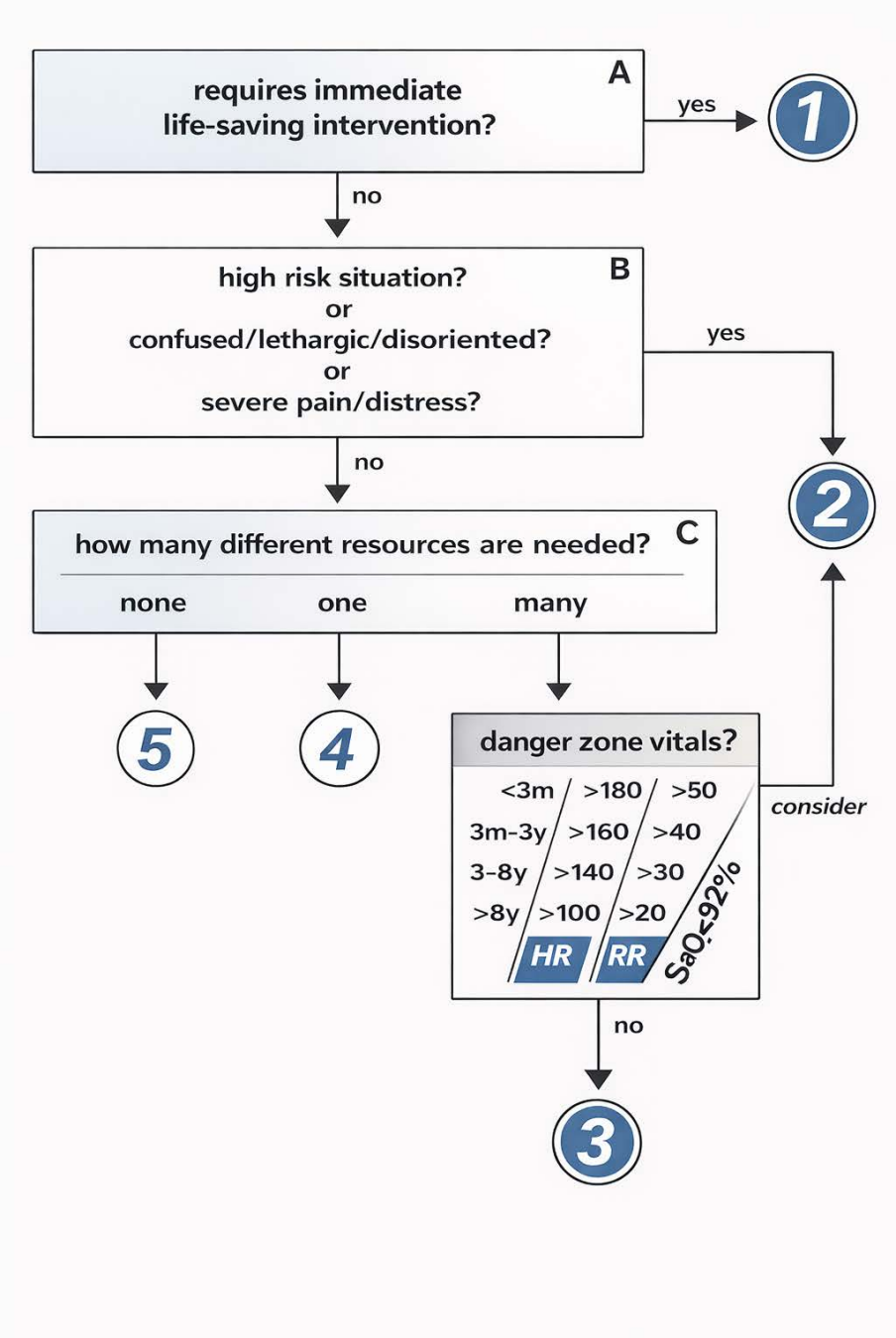
Resources

- Labs □ Blood examination .....
  □ Urine examination .....
- EKG □ EKG 12 leads
- X-rays □ CXR □ Plain abdomen □ KUB □ Others.....
- Other imaging □ CT ..... □ MRI .....
  □ Ultrasound ..... □ Angiography .....
- IV fluids
- Medication routes □ IV □ IM □ Nebulized
- Special consultation
- Refer
- Simple procedure □ Laceration repair □ Foley catheterization
  □ .....
- Complex procedure (conscious sedation) □ .....

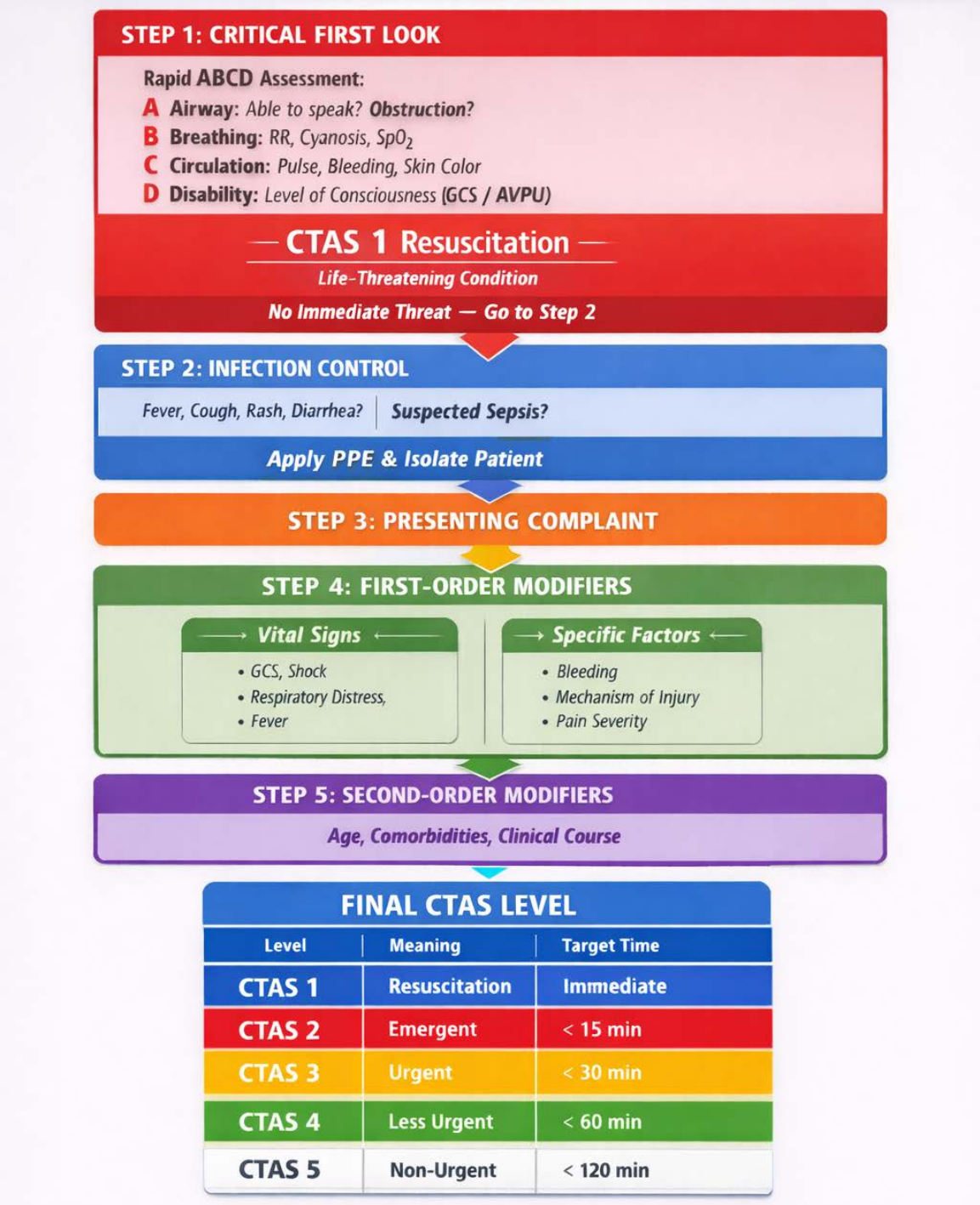
Disposition □ Ward ..... □ Refer out .....
□ ICU ..... □ Discharge

Length of stay in hospital ..... days

Status □ Discharge □ Death □ Refer □ Against advice



Supplementary Figure 1 Emergency Severity Index (ESI) Triage Algorithm, adapted from Emergency Severity Index, Version 4.



Supplementary Figure 2 Canadian Emergency Department Triage and Acuity Scale (CTAS) flowchart, adapted from the Canadian Triage and Acuity Scale participant manual (version 2.5b, November 2013).

Supplementary Table 1. Baseline characteristics stratified by CTAS triage level

Variable	CTAS I (n=24)	CTAS II (n=69)	CTAS III (n=137)	CTAS IV (n=157)	CTAS V (n=26)
Gender, n (%)					
Female	13 (54.2)	37 (53.6)	76 (55.5)	82 (52.2)	16 (61.5)
Male	11 (45.8)	32 (46.4)	61 (44.5)	75 (47.8)	10 (38.5)
Age (year): median (IQR)	64.5 (42,75.5)	61 (33,77)	50 (25,68)	30 (21,47)	26.5 (21,50)
Underlying disease, n (%)	18 (75)	37 (53.6)	69 (50.4)	22 (14)	5 (19.2)
Any comorbidity	6 (25)	32 (46.4)	68 (49.6)	135 (86)	21 (80.8)
No comorbidity					
Type of patient, n (%)					
Traumatic patients	3 (12.5)	8 (11.6)	40 (29.2)	128 (81.5)	21 (80.8)
Non-traumatic patients	21 (87.5)	61 (88.4)	97 (70.8)	29 (18.5)	5 (19.2)
Vital signs at triage: median (IQR)					
SBP (mmHg)	118 (80,156)	132 (109,153)	134 (117,157)	129 (117,145)	126 (110,146)
HR (bpm)	86 (61,104)	99 (84,115)	88 (74,109)	89 (80,100)	85 (75,96)
RR (/min)	26 (18,32)	20 (18,28)	20 (18,22)	18 (16,20)	18 (16,18)
SpO_2 (%)	93 (76,98)	97 (95,98)	98 (96,98)	98 (97,99)	98 (97,99)
BT(°C)	36.3 (36,36.7)	37 (36.7,38.1)	36.8 (36.5,37.2)	36.7 (36.2,37)	36.4 (36,36.7)

SBP = systolic blood pressure, HR = Heart rate, RR = Respiratory rate, SpO2 = peripheral oxygen saturation, BT = Body temperature, IQR = interquartile range

Supplementary Table 2. Baseline characteristics stratified by ESI triage level

Variable	ESI I (n=31)	ESI II (n=98)	ESI III (n=142)	ESI IV (n=90)	ESI V (n=52)
Gender, n (%)					
Female	16 (51.6)	54 (55.1)	78 (54.9)	46 (51.1)	30 (57.7)
Male	15 (48.4)	44 (44.9)	64 (45.1)	44 (48.9)	22 (42.3)
Age (year): median (IQR)	61 (35,70)	60 (31,77)	40.5 (22,64)	25.5 (20,46)	30.5 (21,49.5)
Underlying disease, n (%)					
Any comorbidity	21 (67.7)	60 (61.2)	48 (33.8)	11 (12.2)	11 (21.2)
No comorbidity	10 (32.3)	38 (38.8)	94 (66.2)	79 (87.8)	41 (78.8)
Type of patient, n (%)					
Traumatic patients	3 (9.7)	9 (9.2)	66 (46.5)	74 (82.2)	48 (92.3)
Non-traumatic patients	28 (90.3)	89 (90.8)	76 (53.3)	16 (17.8)	4 (7.7)
Vital signs at triage: median (IQR)					
SBP (mmHg)	111 (81,150)	136 (117,162)	133 (115,152)	129 (117,143)	130 (116,146)
HR (bpm)	96 (70,118)	94 (78,115)	90 (76,104)	84 (76,94)	90 (81,100)
RR (/min)	28 (20,32)	20 (18,28)	18 (18,20)	18 (16,20)	16 (16,18)
SpO_2 (%)	94 (79,98)	97 (95,98)	97 (96,99)	98 (97,99)	98 (97,99)
BT(°C)	36.5 (36,37)	37.1 (36.7,37.7)	36.5 (37.1 (36.6)	36.6 (36.2,36.7)	36.5 (36.1,37.0)

SBP = systolic blood pressure, HR = Heart rate, RR = Respiratory rate, SpO2 = peripheral oxygen saturation, BT = Body temperature, IQR = interquartile range