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Comparison between simple triage and rapid treatment and Taiwan Triage and Acuity Scale for the emergency department triage of victims following an earthquake-related mass casualty incident: a retrospective cohort study

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Abstract

Background: Triage plays a crucial role in the emergency department (ED) management of mass casualty incidents (MCIs) when resources are limited. This study aimed to compare the performance of simple triage and rapid treatment (START) with that of the Taiwan Triage and Acuity Scale (TTAS) for the ED triage of victims following an earthquake-related MCI.

Methods: We retrospectively reviewed the records of victims presenting at our ED with earthquake-related injuries within 24 h of a large-scale earthquake. TTAS was initially used at our ED for this event, and START was performed by retrospectively reviewing the patient records in a blinded manner. Area under the receiver operating characteristic curve (AUC), sensitivity, and specificity of START and TTAS were determined for predicting ED discharge.

Results: We enrolled 105 patients (predominantly women, 60.0%; median age, 45.0 years) in this study; most of them presented with traumatic injuries and were initially triaged as TTAS level III (78.1%), followed by TTAS level II (11.4%). Although the majority of the victims (81.0%) were discharged, four deaths occurred. A moderate agreement in differentiating emergency from nonemergency patients was observed between START and TTAS. Furthermore, both the triage systems showed similar predictions for ED disposition (START AUC/sensitivity/specificity: 0.709/82.35%/55.00%; TTAS AUC/sensitivity/specificity: 0.709/90.59%/45.00%).

Conclusions: The present study demonstrated that START and TTAS have similar triage accuracy and ability to predict ED disposition. Our findings demonstrate that START may be used as an alternative to TTAS for the ED triage of victims following earthquake-related MCIs.

Keywords: Triage, Mass casualty incident, Earthquake, Emergency department triage

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Background

Field triage [1, 2] and hospital triage [3–5] play crucial roles in emergency medical care [6, 7]. The accuracy and efficiency of triage contribute to timely medical treatment and better patient outcomes [8]. However, inappropriate triage protocols may lead to catastrophic consequences, such as misusing valuable resources on overtriaged patients and jeopardizing undertriaged ones [9]. During disastrous scenarios, the efficiency of triage is particularly important for managing casualties when resources are limited [10].

Life-threatening disasters may lead to mass casualty incidents (MCIs), thereby further paralyzing regional health care resources and facilities [11]. While different disasters lead to different types of casualties, some of them such as explosions [12], fires [13], and traffic accidents [14] yield victims with relatively more predictable injuries. Large-scale earthquake-related disasters are characterized by a high number of victims with wide-range disease severity and injuries. The time frame and geographical casualty distribution of MCIs can be highly clustered around the epicenter, thus causing a surge in evacuations and medical demands [11, 15]. Owing to safety considerations, field triage and patient stabilization may not always be plausible, thereby leading to considerable challenges in the emergency department (ED) management of large-scale earthquake-related MCIs. Therefore, an optimal triage system that considers time and precision may improve resource allocation, maintain ED operability, and provide effective treatment to victims.

EDs throughout Taiwan use the Taiwan Triage and Acuity Scale (TTAS) [16], which has been adapted from the Canadian Triage and Acuity Scale (CTAS) [17], as the standard triage protocol to classify patients into five categories according to their acuity. However, TTAS is not specifically designed for situations wherein mass casualties are transported to EDs within a short duration. Using TTAS may result in time- and labor-consuming evaluation during disastrous MCIs, such as large-scale earthquakes. In the USA, simple triage and rapid treatment (START), which had been developed during the 1980s in Orange County, California, has been used as the *de facto* national standard for onsite triage during MCIs [8, 18]. The potential advantages of START include its simplicity, shorter triage time, and lower requirements for provider training [19]. Given that a large proportion of large-scale earthquake-related victims are transported to EDs without field triage [15], adopting START as an alternative triage protocol for the ED management of MCIs is plausible. However, studies demonstrating the use of START in ED settings have been limited, and its triage efficacy has not been verified to date [12, 15]. Indeed, comparing the performances of different triage protocols under the same setting remains an important field of study [20, 21].

On February 6, 2018, at 23:50 local time, a Richter 6.0 earthquake struck Hualien, a county of Eastern Taiwan, which ultimately caused hundreds to be injured, 17 deaths, and four complex building collapses. Government estimates revealed that the earthquake caused over 250 million USD damage. Considering that TTAS had been initially used by our ED for this event, the present study performed START by retrospectively reviewing patient records in a blinded manner and compare the performances of START and TTAS for the emergency department triage of victims following an earthquake-related mass casualty incident. Accordingly, we found that START and TTAS had similar triage accuracy and ability to predict ED disposition.

Methods

Study design and setting

This study was approved by the Institutional Review Board of the Hualien Tzu Chi Hospital Research Ethics Committee, and the need for informed consent was waived. This study was conducted at a tertiary center of Eastern Taiwan, which comprises 970 hospital beds and 76 ED beds. Victims of the Hualien earthquake (occurred on February 6, 2018) who visited our ED were originally categorized according to different acuity levels using the standard TTAS protocol. Records of victims who presented at our ED within 24 h after the earthquake were retrospectively reviewed. All the patients who experienced earthquake-related injuries, including traumas, burns, inhalation injuries, and out-of-hospital cardiac arrest, were included, whereas young patients (aged < 8 years), those who arrived late (arriving > 24 h after the earthquake), and patients with incomplete vital sign records were excluded. The included victims were then re-evaluated using START by two ED clinicians blinded to the TTAS outcomes.

Taiwan Triage and Acuity Scale assessment

TTAS [16], a computerized triage system adapted from CTAS [17], has been the standard emergency triage protocol used in Taiwan. The TTAS level for each patient was generated in real-time by one designated triage nurse who had received specific training on the application of the five-level TTAS protocol and the computer-assisted system. Using the computerized decision support system, patients were classified in descending order of acuity: level 1, resuscitation; level 2, emergency; level 3, urgent; level 4, less urgent; and level 5, nonurgent. TTAS categorizes patients into three domains: nontrauma, trauma, or environmental injuries. The nontrauma domain includes 13 categories and 125 chief complaints, the trauma domain includes 14 categories and 41 chief complaints, and the environmental injury domain includes 11 chief complaints. TTAS

determines triage severity according to (a) chief complaints and (b) first-order modifiers such as vital signs (including respiration, hemodynamics, consciousness level, and body temperature), pain severity, and injury mechanism (for trauma patients). Second-order modifiers are used when first-order modifiers are unable to adequately assign an appropriate acuity level and are specific to a few complaints such as visual disturbance for eye trauma or neurologic deficit for head, neck, and back trauma.

Simple triage and rapid treatment assessment

START acuity was retrospectively determined using recorded ambulatory status, respiratory rate, pulse, and consciousness level. Accordingly, patients who could walk were assigned to the START minor category, those unable to breathe spontaneously were assigned to the deceased category, and those who could not walk, had a respiratory rate of < 30 breaths/min and systolic blood pressure of > 80 mmHg, and were able to follow commands (Glasgow Coma Scale score > 13) were assigned to the delay category. All the other patients were assigned to the immediate category (Fig. 1). Ambiguous cases were clarified and assigned after consensus among the reviewing investigators during data abstraction.

Data collection and processing

Demographic data, including age, sex, TTAS level, ED disposition [discharge, observations, admission to the ward or intensive care unit (ICU), and ED mortality], ED interventions, ED length of stay (LOS), mortality, and ED medical expenses, were obtained. Specific ED interventions analyzed herein included transfusion of blood products and computed tomography (CT) arrangement. ED medical expenses were determined from the Medical Affairs Office of the hospital, excluding the costs of

prehospital care, after ED discharge or admission. Patients were further classified into emergency and non-emergency groups based on either START or TTAS levels. Accordingly, patients in the START immediate and deceased categories were classified into the emergency group, indicating that standard resuscitation was performed on deceased patients, whereas those in the minor and delay categories were classified into the non-emergency group. Moreover, patients triaged as TTAS levels I and II were classified into the emergency group, whereas those triaged as levels III–V were as classified into the nonemergency group.

Outcome measures

The primary outcome was ED discharge rate, whereas the secondary outcomes included ED interventions, ED LOS, 24-h mortality, and ED medical expenses.

Statistical analysis

The Kolmogorov–Smirnov test was used to determine the distribution of continuous variables. Continuous variables were presented as medians [interquartile ranges (IQRs)] and compared using the Kruskal–Wallis test, whereas categorical variables were presented as percentages and compared using the chi-squared or Fisher’s exact test. Kappa statistic was used to describe the consistency between START and TTAS in defining emergency or nonemergency patients. Sensitivity, specificity, positive predictive value, negative predictive value, and area under the receiver operating characteristic (ROC) curve (AUC) of START and TTAS for predicting ED discharge were calculated. A *p* value of < 0.05 indicated statistical significance. Statistical analyses were performed using SPSS (IBM SPSS Statistics for Windows, Version 21.0, Armonk, NY: IBM Corp.) and MedCalc (MedCalc for Windows, Version 19.1, Ostend, Belgium).

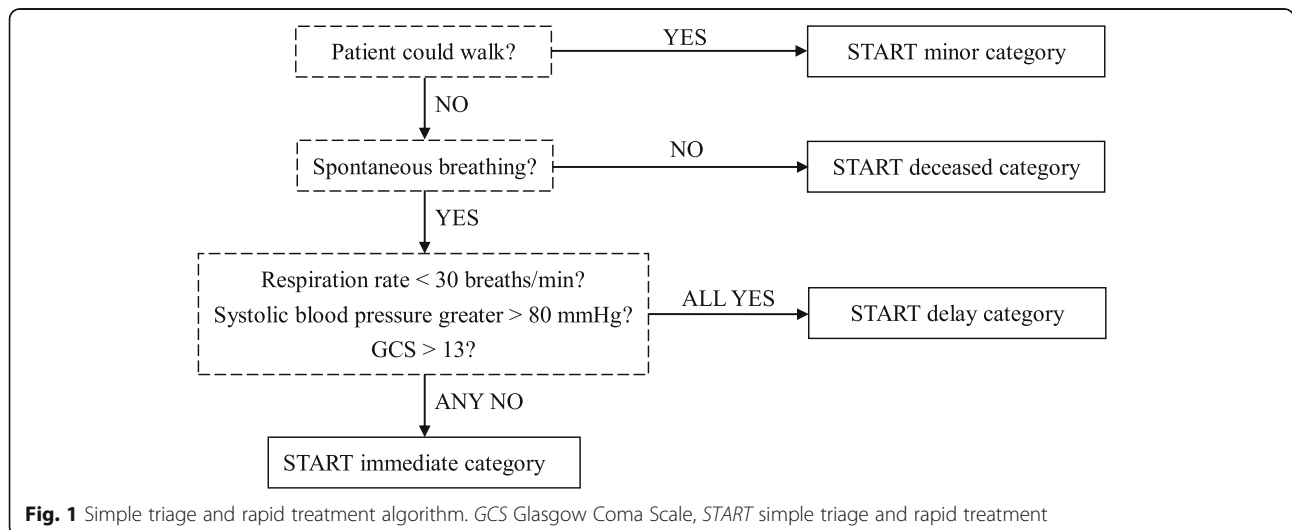


Fig. 1 Simple triage and rapid treatment algorithm. GCS Glasgow Coma Scale, START simple triage and rapid treatment

Results

A total of 144 patients visited the ED at our hospital after the earthquake. Among these, 113 visited our ED within the first 24 h of the earthquake. After excluding 2 patients aged < 8 years and 6 patients with incomplete vital sign records, a total of 105 patients were finally included for analysis (Fig. 2). Most of the patients developed traumatic injuries ($n = 92$), whereas the others developed burn injuries ($n = 5$, 1 of whom also developed trauma), inhalation injury ($n = 5$), and cardiac arrest ($n = 4$). Table 1 presents the demographic characteristics of the study population. Our patients were predominantly women (60.0%) with a median age of 45.0 years. Most of them were initially triaged as TTAS level III (78.1%), followed by TTAS level II (11.4%). Most of the victims were discharged (81.0%), whereas only 4 deaths were noted. The majority of the patients triaged using the START protocol were classified into the minor category, followed by the delay, deceased, and immediate categories. Patients under the START minor category were younger and had higher discharge rates and lower ED medical expenses than those in the other categories. Patients in the START delay category had a higher probability of undergoing CT at the ED than those in the START minor category (38.1% vs. 10.1%; $p = 0.002$). Only 1 and 2 patients in the delay (4.8%) and deceased (50%) categories, respectively, received blood transfusion at the ED. Deaths were only observed in the deceased category, with 3 and 1 patient dying during their ED and ICU stays, respectively. These four mortality cases were

categorized as TTAS level I and were declared out-of-hospital cardiac arrest/dead on arrival. One patient who died had suddenly collapsed shortly after the earthquake without trauma, whereas the other three patients were rescued from a collapsed building with head and/or extremity trauma.

After analyzing the consistency between START and TTAS in differentiating emergency from nonemergency patients, our results revealed a moderate agreement between the two triage systems (Cohen’s Kappa coefficient = 0.41; Table 2). Only 12 patients triaged into the emergency group (level I or II) by TTAS were triaged into the non-emergency group (minor or delay category) by START.

ROC analysis was performed to determine the abilities of START and TTAS to predict ED discharge among our patients (Fig. 3). Accordingly, the AUC for START [0.709 (0.612–0.793)] was not significantly different from that for TTAS [0.709 (0.612–0.794); $p = 0.996$]. Table 3 summarizes the sensitivity and specificity of START and TTAS for predicting ED discharge. Accordingly, our results showed that START and TTAS had similar performances (START sensitivity/specificity: 82.35%/55.00%; TTAS sensitivity/specificity: 90.59%/45.00%). Similarly, START and TTAS had similar performances in predicting ED mortality (START AUC/sensitivity/specificity: 0.995/100%/99.02%; TTAS AUC/sensitivity/specificity: 0.990/100%/98.04%).

Discussion

The present study aimed to compare the performances of START and TTAS in managing the ED triage of

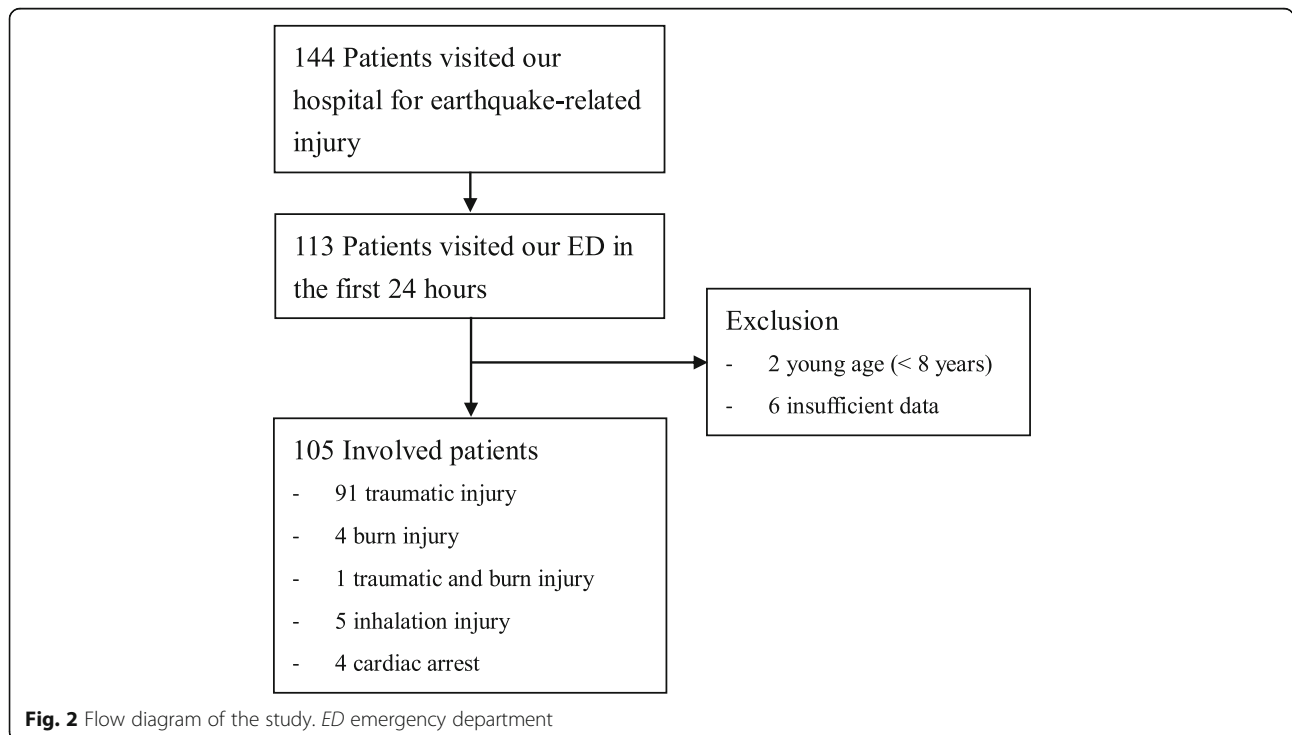


Fig. 2 Flow diagram of the study. ED emergency department

Table 1 Comparison of patient characteristics and outcomes according to START triage categories

	Overall n = 105	Minor category n = 79 (75.2%)	Delay category n = 21 (20.0%)	Immediate category n = 1 (1.0%)	Deceased category n = 4 (3.8%)	p value
Sex, n (%)						0.84
Male	42 (40.0)	33 (41.8)	7 (33.3)	0 (0)	2 (50)	
Female	63 (60.0)	46 (58.2)	14 (66.7)	1 (100)	2 (50)	
Age, years, median (IQR)	45.0 (35.0)	38.0 (32.0)	59.0 (29.5)	80	49.5 (27.8)	0.008*
ED disposition, n (%)						< 0.001*
ED mortality, n (%)	3 (2.9)	0 (0)	0 (0)	0 (0)	3 (75)	
ICU, n (%)	2 (1.9)	0 (0)	1 (4.8)	0 (0)	1 (25)	
Ward, n (%)	8 (7.6)	5 (6.3)	3 (14.3)	0 (0)	0 (0)	
Observation, n (%)	7 (6.7)	4 (5.1)	2 (9.5)	1 (100)	0 (0)	
Discharge, n (%)	85 (81.0)	70 (88.6)	15 (71.4)	0 (0)	0 (0)	
CT, n (%)	18 (17.1)	8 (10.1)	8 (38.1)	1 (100)	1 (25)	0.002*
Blood transfusion, n (%)	3 (2.9)	0 (0)	1 (4.8)	0 (0)	2 (50)	0.001*
ED LOS in hours, median (IQR)	1.02 (1.02)	0.98 (0.89)	1.18 (2.41)	20.03	0.88 (0.41)	0.134
Mortality, n (%)	4 (3.8)	0 (0)	0 (0)	0 (0)	4 (100)	< 0.001*
ED medical expenses, median (IQR), USD	122.7 (164.1)	116.6 (83.4)	173.0 (484.5)	1150	552.7 (327.7)	0.003*
TTAS						< 0.001*
Level I	5 (4.8)	0 (0)	1 (4.8)	0 (0)	4 (100)	
Level II	12 (11.4)	9 (11.4)	2 (9.5)	1 (100)	0 (0)	
Level III	82 (78.1)	66 (83.5)	16 (76.2)	0 (0)	0 (0)	
Level IV	6 (5.7)	4 (5.1)	2 (9.5)	0 (0)	0 (0)	
Level V	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	

START simple triage and rapid treatment, IQR interquartile range, ED emergency department, ICU intensive care unit, CT computed tomography, LOS length of stay, USD United States dollar, TTAS Taiwan Triage and Acuity Scale

victims following an earthquake-related MCI. Our results showed a moderate agreement between START and TTAS in differentiating emergency from non-emergency patients. Furthermore, both the triage systems had similar predictions regarding ED disposition.

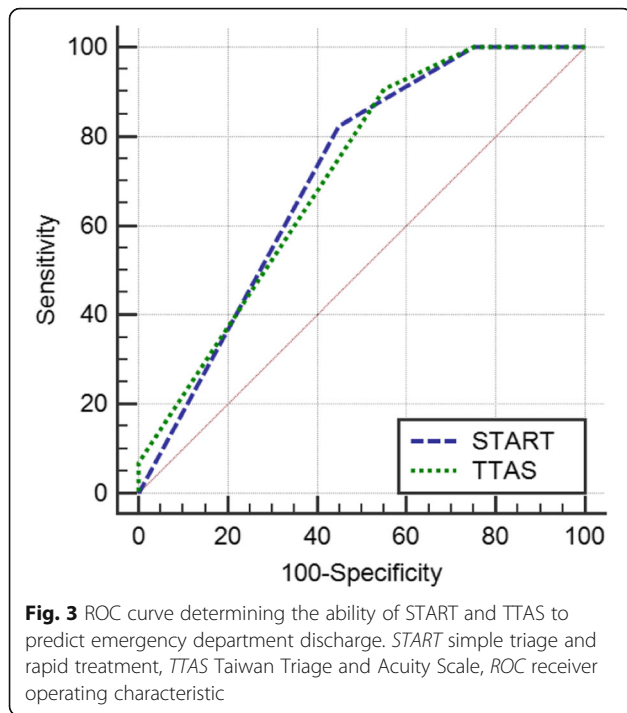
Victims of earthquake-related disasters may present with a wide spectrum of injuries and severities [22–24]. In the present study, traumatic injuries were predominant, followed by burns and inhalation injuries. Earthquake-related MCIs may cause considerable challenges related to workforce and medical resources within the ED. During

such situations, a rapid and accurate triage system is essential for the subsequent management and improvement of patient outcomes. Despite being conventionally used in EDs, TTAS had not been specifically designed for the triage of MCI victims and therefore requires evaluations involving time-consuming, labor-intensive, computer-assisted processes, which may cause delays in patient management following MCIs. Moreover, safety considerations during an earthquake may prevent field triage from being performed. Thus, the use of the START system appears feasible for the ED management of victims of

Table 2 Association between START and TTAS

		START			
		Nonemergency		Emergency	
		Minor category	Delay category	Immediate category	Deceased category
TTAS					
Nonemergency	Level V	0	0	0	0
	Level IV	4	2	0	0
	Level III	66	16	0	0
Emergency	Level II	9	2	1	0
	Level I	0	1	0	4

START simple triage and rapid treatment, TTAS Taiwan Triage and Acuity Scale



earthquake-related MCIs. Indeed, the findings of our study demonstrated that both *START* and *TTAS* had similar triage accuracy and ability to predict ED disposition.

A limited number of studies have compared the performance of *START* with those of other triage systems in an ED setting. Ng et al. [12] conducted a retrospective study using data obtained from casualties following a mass burn incident. After comparing the performances of *START*, *TTAS*, and a mass burn casualty triage system at the ED, they found that *STRAT* had the highest sensitivity but the lowest specificity in predicting ICU admission [12]. Curran-Sills and Franc [19], who investigated the speed and accuracy of *START* and *CATS* (the

original version of *TTAS*) for the ED triage of patients following a simulated MCI, found that triage nurses completed the *START* protocol (33 s/patient) faster than they completed the *CTAS* protocol (138 s/patient), with both the systems showing similar levels of accuracy [19]. Moreover, after comparing the Emergency Severity Index triage levels and *START* colors for urgent care and hospitalization in a triage tag exercise, Hong et al. [25] found that the Emergency Severity Index better identified patients with abnormal vital signs, those who needed emergency interventions, and those who needed hospitalization than *START* [25]. To the best of our knowledge, the present study is the first to compare the performances of *START* and *TTAS* in the triage of victims transported to the ED following a large-scale earthquake.

START had been developed for resource-limited field triage settings, prioritizing patients in the *START* immediate category who are more probable to survive rather than those in the deceased category. Conversely, *TTAS* had been designed as a triage system for patients arriving at EDs, prioritizing the most severe patients (*TTAS* level I patients). The present study demonstrated that victims in the deceased category had a 100% mortality rate even after standard in-hospital resuscitation efforts and higher medical expenses compared with those in the other categories. Nevertheless, we suggest that patients in the *START* deceased category be prioritized when the aforementioned triage system is alternatively used for evaluation in EDs.

Among the 12 patients with discrepant triage results (emergency by *TTAS* but nonemergency by *START*), 9 had head injuries, whereas 3 had upper extremity injuries. Among those with head injuries, an 87-year-old male patient diagnosed with a brain concussion had been admitted to the ICU for further observation over 3 days. This patient was triaged as *TTAS* level I and retrospectively classified in the *START* delay category, whereas the

Table 3 *START* and *TTAS* protocols for predicting disposition (ED discharge vs. observation/admission/death)

	<i>START</i>		<i>TTAS</i>	
	Minor category	Delay/immediate/deceased category	Levels III–V	Levels I and II
ED discharge, <i>n</i>	70	15	77	8
Observation/admission/death, <i>n</i>	9	11	11	9
AUC, 95% CI	0.709 (0.612–0.793)		0.709 (0.612–0.794)	
Sensitivity, 95% CI	82.35 (72.57–89.77)		90.59 (82.29–95.85)	
Specificity, 95% CI	55.00 (31.53–76.94)		45.00 (23.06–68.47)	
PPV, 95% CI	88.61 (82.59–92.73)		87.50 (82.40–91.28)	
NPV, 95% CI	42.31 (28.56–57.36)		52.94 (33.17–71.83)	
Accuracy, 95% CI	77.14 (67.93–84.77)		81.90 (73.19–88.74)	

START simple triage and rapid treatment, *TTAS* Taiwan Triage and Acuity Scale, *ED* emergency department, *AUC* area under the receiver operating characteristic curve, *CI* confidence interval, *PPV* positive predictive value, *NPV* negative predictive value

remaining 8 patients had been discharged from the ED. Although concerns have been raised regarding the possibility of overtriage with START [26, 27], the present study demonstrated no such tendency after comparing the results for START and TTAS.

Large-scale earthquake-related MCIs are rare, but they substantially increase the difficulty in the triage and management of victims at EDs. Therefore, the data presented in the present study may be of considerable value. However, some limitations of this study are noteworthy. First, given the retrospective nature of this study and the small number of patients included, selection bias may have affected our results. Second, the effects of certain confounders such as triage nurse experience and potential factors influencing physician judgment have not been determined. Third, this study was conducted at a university-affiliated teaching medical center following a large-scale earthquake, which might limit the generalizability of our findings. Therefore, further retrospective or prospective research is needed to validate the use of START at EDs when large sample sizes of patients following either large-scale earthquakes or other MCIs are encountered in the future. However, a prospective randomized study using the START and TTAS triage systems at EDs following MCIs is feasible only with both the validation of the use of START by more retrospective observations and the careful consideration of ethical issues. If randomized studies yield promising results, START may be considered as the main triage system for victims of large-scale earthquakes or other MCIs.

Conclusions

The present study demonstrated that START and TTAS had similar triage accuracy and ability to predict ED disposition. Given that START allows shorter triage times compared with TTAS, our findings suggest that START is an alternative to TTAS for the ED triage of victims of earthquake-related MCIs. However, the findings of our study need to be elucidated in further investigations.

Abbreviations

AUC: Area under the ROC curve; CI: Confidence interval; CT: Computed tomography; CTAS: Canadian Triage and Acuity Scale; ED: Emergency department; ICU: Intensive care unit; IQR: Interquartile range; LOS: Length of stay; MCI: Mass casualty incident; ROC: Receiver operating characteristic; START: Simple triage and rapid treatment; TTAS: Taiwan Triage and Acuity Scale

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Authors' contributions

YKL and KYN contributed to the design of the study, the acquisition of data, the analysis, and interpretation. PFL, CJS, and YMW provided critical revisions. JHW conducted the statistical analysis of the data. PFL and KYN provided the final approval of the version to publish. All the authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of the Hualien Tzu Chi Hospital Research Ethics Committee (approval no. IRB107-194-B), and the need for informed consent was waived.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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