Original Article

Validity and Reliability of the Modified Emergency Severity Index (ESI) Version 4 for Pediatric Triage in the Emergency Department, Songklanagarind Hospital, Thailand

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Objective: The triage algorithm of the modified Emergency Severity Index (ESI) version 4 has established validity and reliability in adults but has not been adequately evaluated in pediatric triage. The present study aimed to assess the validity and reliability of the modified ESI version 4 in pediatric triage in the emergency department.

Materials and Methods: Between January and December 2015, 1,193 patients were enrolled. The inter-rater reliability was measured with kappa statistics. Validity was evaluated by comparison with the ESI ratings with outcomes including disposition and resource consumption.

Results: One thousand one hundred ninety-three patients, including 684 boys and 509 girls, were enrolled in the present study. Most of the patients were three to eight years old and the most three common presentation at the ED were fever (24.2%), dyspnea (16.0%), and upper respiratory tract infection (2.8%), respectively. Only six (0.5%) patients received life-saving intervention and 572 (81.5%) were discharge home with medications. There were 523 cases (43.84%) in which the triage nurses and researcher assigned a similar triage rating (weighted kappa 0.25 (0.22 to 0.29), p<0.001), while 302 cases (25.31%) were over-triage and 368 cases (30.85%) were under-triage. The correlation coefficient between disposition and triage level was 0.37 (p<0.001). Resource consumption increased significantly in the lower triage level (correlation coefficient, p<0.001).

Conclusion: The present study showed a low validity and reliability using ESI tool for triage pediatric patients in emergency department at Songklanagarind Hospital.

Keywords: Triage, Pediatrics, Emergency department

J Med Assoc Thai 2019;102(4):449-54
Website: http://www.jmatonline.com

The emergency department (ED) is the important gateway for patients in life-threatening conditions who need immediate resuscitation or life-saving procedures[1]. The number of patients visiting the ED is steadily increasing[2,3]. However, some patients do not have any urgent conditions which result in ED overcrowding, delayed time-sensitive disease decisions, and poor treatment that affect health related outcomes[4,5].

Therefore, the triage system is an important tool to prioritize patients and reduce ED overcrowding in a resource-limited hospital[6,7]. The American College of Emergency Physicians and the Emergency Nurses Association advocate for a triage system in the ED[8]. The emergency severity index (ESI) triage algorithm was originally developed by David Eitel and was applied for use in hospitals in 1999. The main purpose is to identify patients needing immediate care and prioritize patients by predicting the resources needed. The ESI is now in version 4[9-11].

In 2012, the Emergency Medical Committee of Thailand announced the modified ESI v.4 in Thailand for trained health care providers. The main difference from the original is the danger zone of vital signs

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How to cite this article: Wuthisuthimethawee P, Boonchai P. Validity and Reliability of the Modified Emergency Severity Index (ESI) Version 4 for Pediatric Triage in the Emergency Department, Songklanagarind Hospital, Thailand. J Med Assoc Thai 2019;102:449-54.

before thinking of the resources required. It has established validity and reliability mostly in adults. In pediatric patients, the physical and emotional responses from injury and illness differ from adults due to the physiology. Therefore, the ESI v.4 considers the vital signs to increase the efficacy of this triage tool[12,13]. The aim of the present study was to assess the validity and reliability of the modified ESI v.4 for pediatric triage in the ED at Songklanagarind Hospital.

Materials and Methods

Study design

A retrospective analytic study was conducted in 1,193 patients younger than 15 years old who visited the ED in 2015. The triage categories were extracted from the medical records in the Hospital Information System (HIS).

The triage accuracy was defined as the synchronization of ratings between the triage nurses, physicians, or emergency medicine resident compared with the research physician. The inter-rater reliability was defined as the agreement between nurses and physicians who rated the ESI level. The authors defined validity as the agreement between the ESI level and its true value, which was evaluated from the patient outcomes.

Accuracy was assessed by the triage nurses, physicians, and emergency medicine resident ratings compared with the ratings of the research physician who reviewed the resources used in the actual pediatric patients. Reliability was assessed in actual pediatric patients who were rated by triage nurses and physicians. Validity was assessed by comparing the ESI level with the outcomes including disposition and resource consumption.

The present study was approved by the Research Quality and Safety Control Committee of Prince of Songkla University. The expenditures were supported by the Faculty of Medicine, Prince of Songkla University.

Study setting and population

The present study was performed at the ED of Sonklanagarind Hospital in Hat Yai, Songkhla, Thailand that receives about 49,000 patients annually, including 5,000 children. The sample size was calculated to have a substantial to good interrater reliability (Cohen's kappa of 0.8 or greater)[14,15]. A computer-based randomization system selected 1,193 patients younger than 15 years who visited the ED between January and December in 2015. The patients who left the ED without being seen by a physician or were not rated by a nurse or physician were excluded from the study.

Study protocol

The modified ESI v.4 was used for triage by the physicians, triage nurses, and the research physician. The physicians were in their internship or different academic years residency in emergency medicine resident who worked in each shift. The triage nurses had at least five years of experience working in the ED and had been trained in modified ESI v.4 by attending emergency physician and triage nurse experts. The research physician was a third-year emergency medicine resident.

Nurses, physicians, and the research physician were trained to complete the modified ESI v.4 triage protocol. The nurses in charge measured the pulse, blood pressure, and oxygen saturation with the Philips SureSigns VM4, body temperature with an electronic thermometer, pain level with the Numeric Pain Intensity Scale (if capable), and breathing frequency.

The modified ESI v.4 algorithm assigned the patients into groups 1 to 5, (1 is most urgent and 5 is least urgent). ESI Level 1 patients require immediate life-saving intervention or they present with unresponsiveness, apnea, pulselessness, intubation or severe respiratory distress. ESI level 2 patients are confused, lethargic, disoriented, have severe pain/distress or have a high-risk situation, and patients within danger vital signs. ESI level 3 patients have more than one resource needed. ESI level 4 patients need a single resource. Lastly, ESI level 5 patients need no resources and require only history taking and physical examination. The ESI level 1 and 2 patients had immediately access to emergency care while ESI 3, 4, 5 waited for 30 minutes, 1 hour, and 2 hours, or less according to situation in the ED. Furthermore, all ESI level 3, 4, 5 patients received re-triage within 30 minutes, 1 hour, and 2 hours by triage nurse.

The reference for triage category was assigned by the research physician and the supervisor according to clinical, physiologic parameters, disposition, and resource consumption.

Data analysis

Demographic information including age, sex, medical problem, and disposition variables including discharge, referral, admission status, location of the admission, and death were documented.

For the data analysis, the authors used R software version 3.2.2. Frequency and percentages were used for qualitative data, while median and interquartile

range were used for quantitative variables. The inter-rater reliability between the triage nurses and physicians were measured by unweighted and weighted kappa statistics. The relationships between each ESI level and disposition and resource consumption were evaluated with the Spearman's rank correlation coefficient.

Results

One thousand two hundred thirty-eight pediatric patients were enrolled into the present study. Forty-five patients were excluded from the study as 43 patients did not have an ESI rating and two patients had misinformation data. Therefore, 1,193 patients remained in the present study for the data analysis. The demographic information is shown in Table 1.

The vital signs were incompletely collected. The rates of collected data on the pulse rate, respiratory rate, blood pressure, body temperature, oxygen saturation, and pain scale were 91.95%, 85.66%, 84.74%, 77.70%, 37.89%, and 0.25%, respectively.

The accuracies of the ESI ratings by the triage nurses, physicians, and emergency medicine resident compared with the research physician were 33.78%, 18.35%, 17.97% respectively. The percentages of emergency medicine resident, physicians, and triage nurses who rated the patients more critically with lower triage levels (over-triage) compared to the research physician were 59.49%, 51.80%, and 20.03%, respectively. Conversely, the percentages of triage nurses, physicians, and emergency medicine resident who assessed the patients less critically giving higher triage levels were 46.18%, 29.84%, and 22.53%, respectively. The greatest ESI rating discordance of all three groups was in level 2.

In 1,193 cases, the triage nurses and physicians ESI ratings were compared. There were 523 cases (43.84%) in which the triage nurses and physicians assigned a similar triage rating while in 302 cases (25.31%) the triage nurses rated patients more critically with lower triage levels (over-triage) compared to the physicians, and in 368 cases (30.85%) the triage nurses assessed the patients less critically giving higher triage levels. The greatest ESI level discordance was in level 4 where 171 cases were triaged in level 5 and 202 cases were triaged in lower levels by the triage nurses. The weighted and unweighted kappa (measure of agreement) between the triage nurses and physicians showed fair concordance (Table 2).

In 395 cases the ratings of the triage nurses and emergency medicine resident were compared. In 157 cases (39.75%) the triage nurses and emergency

Table 1. Demographic characteristics, age, sex, medical problem, immediate life-saving intervention, and disposition

Characteristic	Number of patients (n = 1,193) n (%)
Sex	
Male	684 (57.3)
Female	509 (42.7)
Age*	
<3 months	97 (8.1)
3 months to <3 years	338 (28.3)
3 years to <8 years	429 (36)
>8 years	329 (27.6)
Problem	
Medical	943 (79.0)
• Fever	289 (24.2)
• Dyspnea	191 (16.0)
• Rash	31 (2.6)
• URI	34 (2.8)
• Vomit	88 (7.4)
• Diarrhea	58 (4.9)
• Abdominal	56 (4.7)
• For prescription	12 (1.0)
• By appointment	7 (0.6)
• Referral	22 (1.8)
• Other	159 (13.3)
Trauma	250 (21.0)
• Trauma-multiple, other, or unspecified	144 (58.1)
• Extremity injury	104 (41.9)
Life-saving interventions	
Received (medical only)	6 (0.5)
Not received	1,187 (99.5)
Disposition	
Discharge	972 (81.5)
Hospital admission	206 (17.3)
Discharge due to denied admission	15 (1.3)
Required hospital admission	
Referred	18 (8.7)
Admitted to the ward	175 (85.0)
Admitted to the ICU	13 (6.3)

URI=upper respiratory infection; ICU=intensive care unit

* Age divide by age group of danger zone vital signs

Table 2. Inter-rater reliability

Kappa	Group		p-value
	Nurses vs. emergency medicine resident	Nurses vs. physicians	
Weighted kappa (95% CI)	0.27 (0.21 to 0.33)	0.25 (0.22 to 0.29)	<0.001
Unweighted kappa (95% CI)	0.13 (0.07 to 0.19)	0.15 (0.12 to 0.19)	<0.001

CI=confidence interval

Table 3. Distribution of research physician ESI ratings compared with disposition

Rating by research physician	Hospital admission n (%)	Discharged due to refused admission or treatment* n (%)	Discharged n (%)	Total n (%)
Level 1	8 (57.1)	1 (7.1)	5 (35.7)	14 (100)
Level 2	123 (21.0)	10 (1.7)	453 (77.3)	586 (100)
Level 3	62 (42.2)	3 (2.0)	82 (55.8)	147 (100)
Level 4	2 (1.4)	1 (0.7)	140 (97.9)	143 (100)
Level 5	11 (3.6)	0 (0.0)	292 (96.4)	303 (100)

ESI=Emergency Severity Index

* Patients refused admission or treatment from various reasons

medicine resident assigned similar triage levels, while in 123 cases (31.14%) the triage nurses rated patients more critically with lower triage levels. In 115 cases (29.11%) the triage nurses assessed patients less critically by giving higher triage levels. The greatest discordance in the ESI level was level 4 where 46 cases were triaged in level 5 and 66 cases were triaged in lower levels by the triage nurses. The weighted and unweighted kappa of the triage nurses showed fair concordance with the emergency medicine resident (Table 2). The correlation coefficient between the disposition and triage level assigned by the triage nurses and the research physician was 0.25 ($p<0.001$).

Fourteen patients were assigned in ESI level 1 by the research physician where six patients presented with dyspnea and desaturation (SpO_2 <90%), but five patients were discharged home when the clinical condition improved after bronchodilator, and the other patient refused hospital admission and revisited the ED the same day. Of the 586 patients in ESI level 2; 463 patients were discharged; 27 patients presented with a high risk complaint (febrile convulsion, seizure, abnormal movement, chest discomfort, severe pain, and transient cyanosis), 170 patients had respiratory problems that responded dramatically to beta-agonist inhalation, and the remaining 266 patients had danger zone vitals of which 169 patients used no resource. There were 147 patients in ESI level 3 where 85 patients were discharged, and 62 patients were admitted. In ESI level 4, three patients were admitted out of 143 patients. In ESI level 5, out of 303 patients, 20 patients were admitted (Table 3).

Resource consumption also varied significantly by ESI level according to the Kruskal-Wallis test ($p<0.001$). The most common resources were laboratory studies (28.90%), intravenous (IV)/intramuscular (IM)/nebulized medication (25.70%), specialist consultations (21.80%), radiography (18.50%), and intravenous fluid (11.10%) as shown in Figure 1.

Discussion

In the present study, 1,193 actual pediatric patient cases assigned by triage nurses versus emergency medicine resident and triage nurses versus physicians had fair agreement ratings [weighted kappa 0.27, 0.25 ($p<0.001$); unweighted kappa 0.13, 0.15 ($p<0.001$)]. There was a weak correlation between disposition and triage level assigned by triage nurses and the research physician (Spearman's coefficient 0.37, 0.22; $p<0.001$). Resource consumption was also significantly related with the ESI level (Kruskal-Wallis test, $p<0.001$).

Several studies have found moderate to high rates of inter-rater reliability and significant validity using the ESI v.4 in pediatric patients performed mostly in children's hospitals[14-17]. Jafari-Rouhi et al demonstrated the ESI had reliability and very good

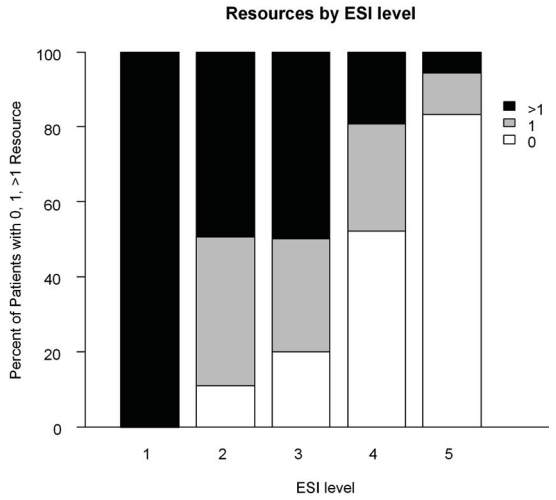

Figure 1. Resources by nurse' ESI level.

n = 1,193 patients, Kruskal-Wallis test, p<0.001

agreement between pediatric emergency medicine physicians and pediatric triage nurses (kappa 0.82, p<0.001). The analysis also showed the likelihood of admission clearly increased as the ESI score decreased (p<0.001)[14]. Durani et al presented high agreement for triage assessment used by pediatric emergency medicine physicians and pediatric triage nurses (weighted kappa 0.92, p<0.001)[15]. Therefore, the ESI is a suitable tool for identifying severe cases that were in levels 1 to 3 (p>0.05) and helped to predict hospital admission and resource consumption[18,19].

The present study found the rating accuracies by the triage nurses, physicians, and emergency medicine resident compared with the research physician were quite low. The consequence of under-triage impacts patient safety, whereas over-triage results in the wasting of resources.

Reliability assessment is sensitive and relates to the availability of manpower and the environment of the ED. For example, physicians had a short period in the ED (i.e., internships who rotated every month and emergency medicine residents who worked in the ED for 1 to 3 years) so they also had less experience to use the ESI tool. Nurses assigned to be triage nurses need at least five years of experience working in the ED. However, since nursing manpower is limited, nursing assistants, paramedics or EMTs substitute as nurses in some periods. The research physician rated patients following the modified ESI v.4 algorithm and the document was reviewed from data and real resource usage. But some cases did not need resource that effect to ESI level 3 to 5. The results of the ratings showed a fair agreement between the triage nurses versus the physicians and the triage nurses versus the EPs.

The validity was assumed from the disposition while some patients had clinical conditions and vital signs that improved dramatically after treatment, which resulted in a low validity. There were many ESI level 4 and level 5 patients who needed admission. The modified ESI v.4 requires experience and expertise to identify critical patients. Therefore, focusing on the danger vital signs also helps to detect high-risk patients.

The present study have some limitations. Songklanagarind Hospital is not a dedicated children's hospital, therefore, pediatricians were not readily available at the ED. There were many referral cases and patients who had made appointments for admission also visited the ED. In addition, many patients came to ED for filling prescriptions.

Conclusion

The present study showed low validity and reliability, which was different from the previous research studies. The authors conclude that the ESI tool needs experienced users. The point to consider from the study is the role of education. However, more research is needed to confirm the modified ESI v.4 can improve the validity or reliability of the ESI tool for inexperienced triage persons.

What is already known on this topic?

According to the abstract, the ESI has proved to be reliable only in adult triage.

What this study adds?

The ESI tool needs triage knowledge and work-experienced users. The danger zone vital signs can predict patients who do not need resources and can be discharged to a higher level, especially in patients older than eight years.

Acknowledgement

The author would like to thank the Epidemiology Unit for suggestions concerning the data analysis and interpretation, Kingkarn Waiyanak for data retrieval and analysis, Glenn Shingledecker for editing the manuscript, and the Faculty of Medicine for funding this research.

Compliance with ethical requirements

The Institutional Ethics Committee Board approved the present study.

Authors' contributions

Boonchai P designed and performed the research, wrote the paper, and analyzed the data. Wuthisuthimethawee P supervised the design, performed, and analyzed the research.

Conflicts of interest

The authors declare no conflict of interest.

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