ORIGINAL ARTICLE

Evidence of the validity of the Emergency Severity Index for triage in a general hospital emergency department

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Objective. To determine whether the Emergency Severity Index (ESI) is valid for triage according to evidence based on classifying real patients in a general referral hospital's emergency department.

Methods. Observational, cross-sectional descriptive study carried out in the emergency department of Hospital Clínico Universitario Virgen de la Arrixaca in Murcia. Thirty-two nurses used the ESI algorithm to triage 410 patients as they arrived seeking care. The results were compared to a gold standard (a triage expert's opinion, which was later confirmed by an expert committee after discussion, if necessary, of cases for which opinions were not unanimous). We calculated sensitivity, specificity, under- and over-triage rates, as well as descriptive statistics about resource assignment, exitus, patients who left without being seen, destination on discharge, and times.

Results. ESI was highly correlated with resources (ρ = –0.717, *P* < .01) and moderately correlated with destination on discharge (ρ = –0.437, *P* < .01). Regarding time spent in the department, we found that patients assigned ESI levels 1 and 2 had significantly longer stays, and those assigned ESI levels 4 and 5 had significantly shorter stays (p < 0,001). Interobserver agreement was good or very good, indicating that this triage tool is reliable.

Conclusions. This pilot of the ESI triage algorithm in the emergency department of a referral hospital found evidence supporting the system's validity.

Keywords: Triage. Emergency Severity Index. Hospital emergency health services. Nursing.

Evidencias de validez del sistema de triaje Emergency Severity Index en un servicio de urgencias de un hospital general

Objetivo. Obtener evidencias de validez del sistema de *triaje* Emergency Severity Index (ESI) en una experiencia con pacientes reales en el servicio de urgencias (SU) de un hospital general.

Método. Estudio observacional, descriptivo, transversal, realizado en el SU del Hospital Clínico Universitario Virgen de la Arrixaca (Murcia). Participaron 32 enfermeros que realizaron 410 experiencias de *triaje* (utilizando el algoritmo del sistema de *triaje* ESI) en pacientes reales que acudieron a urgencias. Los resultados se compararon con un patrón oro representado inicialmente por la opinión de un experto en *triaje* y corroborado posteriormente por un comité de expertos tras una discusión de consenso en los casos en que fue requerido (opiniones no unánimes). Se calculó la sensibilidad, la especificidad, subtriaje, sobretriaje y los estadísticos descriptivos de las variables recursos, fallecimiento/fuga, destino y tiempo de estancia.

Resultados. Los recursos y el destino con el nivel ESI arrojaron correlaciones altas para la primera R_{ho} = –0,717, p < 0,01 y moderadas para la segunda R_{ho} = –0,437, p < 0,01. En el tiempo de estancia según el nivel ESI se observó que los pacientes con niveles ESI 1 y 2 fueron los que permanecieron más tiempo, y con niveles 4 y 5 los que menos, y estas diferencias fueron estadísticamente significativas (p < 0,001). El acuerdo interobservador fue bueno o muy bueno y refuerza la fiabilidad de la herramienta.

Conclusiones. Se han obtenido evidencias de validez en la aplicación piloto del sistema de *triaje* ESI en un hospital de referencia.

Palabras clave: *Triaje.* ESI. Servicio de urgencias hospitalario. Enfermería.

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Article information:
Received: 28-4-2015
Accepted: 5-6-2015
Online: 4-9-2015

Introduction

Overcrowding in emergency departments (EDs) has an overall impact on the health outcomes of patients. The discrepancy between required and available resources, the complexity of patient requirements and the imbalance between numbers of admissions and discharges have been identified as causes of ED overcrowding[1-4]. These factors justify the need for a structured triage system that serves as the backbone of care at EDs[5]. In a structured triage system, the sole determinant of care allocation is the level of emergency[6], defined as the potential of a medical condition to worsen a patient's health depending on time elapsed and the care provided.

The Emergency Severity Index (ESI)[7] is a triage system divided into five levels and based on a decision-making algorithm developed in the late 1990s in the United States. Through a series of specific questions,

the triage nurse applies the algorithm and prioritises treatment. Firstly, the questions identify life-threatening unstable conditions (level 1) or conditions at risk of becoming life-threatening (level 2). These levels require immediate and urgent care respectively. If not the top two, patients are assigned to the lower levels (ESI 3-5) in which the type of resources the patient is estimated to consume is the key determinant.

In absolute terms a triage scale is valid when it assigns the priority level each patient actually requires according to the urgency and seriousness of their complaint. However, in practice, there is no tool for checking if that is the case. A scale's validity is indirectly estimated by relating the different triage groups with their ED care results: length of stay, morbidity, mortality, hospitalisation and resource consumption. A triage scale is all the more valid the better it can predict ED care results[8].

At some point, validity was consensually considered a unitary concept[9,10] and evidence of validity was sought. Validity of the ESI has been extensively evaluated in its native country, the US. Validation studies found strong correlations of ESI and hospitalisation, length of stay in EDs and mortality[11-14]. ESI validation studies conducted in Netherlands[15], and the Germany-Switzerland[16] have obtained similar results.

This paper is a continuation of the publication "Design and validation of a clinical simulation method for teaching nurses to use the Emergency Severity Index for triage"[17]. The original study had three stages (theoretical knowledge, skill acquisition and applicability) and compared results of clinical simulation sessions and real ED clinical practice. Nurses participated in a triage training program, and then participated in clinical simulation to test their skills. The aim was to measure inter-observer agreement and identify areas of improvement without risk to the patient. This methodology has been used successfully in other projects[18,19].This paper deals with the follow-up care of patients in the phase of applicability and aims to obtain evidence of the validity of the ESI triage system with real patients in hospital EDs.

Method

An observational, descriptive, cross-sectional study was carried out in the ED of the University Hospital Virgen de la Arrixaca (HCUVA), province of Valencia, Spain, from January to February 2014. Thirty-two ED nurses with at least 1 year of triage experience participated in the study. They all had undergone the clinical-simulation-based ESI triage training included in the 'theoretical knowledge' and 'skill acquisition' phases of the project. However they lacked real experience in emergency triage. From 9:00 to 10:00 hours Monday to Friday, the first 10 patients to visit the ED were registered twice, first by a physician (gold standard) with ample experience in triage and then by a participant nurse. A total of 410 patients were included and the following data was collected:

1) Resources: complementary examinations, procedures, referrals, interventions, and any other activity not included in their history or physical examination. The ESI implementation manual criteria establish the resources to include[7].
2) Deaths or discharge against medical advice (DAMA): death of the patient during their stay in the ED or discharge without being treated.
3) Destination: hospital or home discharge.
4) Length of stay in ED: time in minutes from ED arrival until their destination is assigned.

As in other studies on triage systems[20,21], the chosen evidence of the validity were overtriage, undertriage, sensitivity and specificity.

Furthermore, this study aimed to evaluate the expert used as gold standard[17]. A new expert group was chosen according to the following criteria: 1) proven experience in ESI triage, 2) availability and motivation to participate in the study, and 3) impartiality. The selected experts were three doctors and a university professor. All were ESI trained and accredited, with at least 2 years' experience in structured triage. The nurses' triage notes were entered in a computer database structured around two variables: number and case report. The expert group reviewed the cases where there was no agreement between the nurse and the initial expert. Once the cases were evaluated, the group gathered and compared results. If they did not reach an agreement, the ESI level was decided through discussion. The group consensus was considered the gold standard for comparison with the results obtained by nurses and the initial expert. A hypothesis that the initial experts would reach a higher level of agreement with nurses was established. This is not commonly reviewed in publications about triage system validation. However it was considered essential for obtaining evidence of validity and consensus[10,22].

Evidence was assessed calculating sensitivity, specificity and descriptive statistics (mean, standard deviation, frequency and percentage) of four resource variables: death, DAMA, destination after discharge and length of ED stay. The association between resources/destination and the ESI level was assessed using Spearman rho. Statistically significant differences between the length of ED stay and ESI level assigned were tested using one-way ANOVA. Overtriage was defined as the percentage of patients assigned a more urgent triage class by nurses than by the experts, and undertriage as the percentage of patients assigned a less urgent triage class by nurses than by the experts. Agreement of the initial experts and the nurses in this study was analysed using unweighted kappa coefficient. A weighted kappa-square coefficient[23], an analysis recommended by some authors for ordinal scales like ESI, was applied and the levels proposed by Landis and Koch for assessing agreement were adopted[24]. In addition, descriptive statistics of socio-demographic variables such as age and gender were included as well as the reasons for the ED visit. Data analysis was performed using SPSS v.21.0.

This study fulfilled all ethical considerations, and the rights of the persons who voluntarily participated in it were not violated. Informed consent from patients and approval from the ethical research committee of the hospital were also obtained.

Results

The final sample consisted of 410 patients, 167 (40.7%) male and 243 (59.3%) female, with a mean age of 49 years and a standard deviation of 20 years. The distribution of the sample by ESI triage level and reason for visiting the ED was heterogeneous (Table 1).

A total of ten DAMA cases (2.4%) and four deaths (1%) were recorded. Since resource variables, destination and length of stay could not be assessed for those ten DAMA cases, the final sample size was 400 patients.

The number of consumed resources as defined by the ESI algorithm matched the ESI level assigned (Table 2). Patients assigned levels 1, 2 and 3 were the most likely to consume more than one resource, those in level 4 consumed one and those in level 5 consumed zero resources (Figure 1). The Spearman rho between the ESI level and the number of resources consumed was Rho = -0.717, $p < 0.01$, indicating a strong association between the two variables. The destination of patients according to ESI level is shown in Table 2. The relationship between the destination variable (hospital admission or discharge home) and the ESI level was Rho = -0.437, $p < 0.01$, a moderate association. Figure 2 shows the number of patients admitted and discharged according to their ESI level. Figure 3 shows length of stay in the ED according to the ESI level. Patients with levels 1 and 2 were those who stayed longer, while those with levels 4 and 5 stayed the least time (Table 2), with statistically significant differences, $F(4) = 14.457$, $p < 0.001$.

The percentages of overtriage and undertriage were low. Overtriage occurred with levels 4 and 5, while undertriage occurred with levels 2 and 3. Thus, high values of sensitivity and specificity were obtained (Table 2).

Table 3 shows the unweighted and weighted kappa-square values used to measure the level of agreement between three pairs of results: 1) initial expert & nurse, 2) expert group & initial expert, and 3) expert group & nurse. The value of the unweighted and weighted-square kappa for the first pair indicated good agreement, with unweighted K = 0.68 ($p < 0.001$), 95% CI [0.651, 0.717] and weighted K-square = 0.81 ($p < 0.001$), 95% CI [0.67, 0.94]. The results of pair comparisons 2 and 3 were even better, with unweighted kappa and weighted kappa-square values that suggest very good agreement. The level of agreement between the new expert group and the initial expert was greater than between the new expert group and the nurses (Table 3).

Discussion

This study aimed to obtain evidence of validity of the ESI triage system through an experience with real patients in the ED of a hospital in Spain. Three reasons undelay the choice of the ESI triage system. Firstly, its

Table 1. Descriptive statistics of sociodemographic variables (sex and age), reasons for consultation and triage levels

	Men n (%)	Women n (%)	Total n (%)
Age (mean and SD)	49 (20)	48 (20)	49 (20)
ESI level assigned by experts			
1	3 (1.8)	0	3 (0.7)
2	23 (13.8)	38 (15.6)	61 (14.9)
3	67 (40.1)	83 (34.2)	150 (36.6)
4	56 (33.5)	88 (36.2)	144 (35.1)
5	18 (10.8)	34 (14)	52 (12.7)
Distribution of cases by reason for consultation			
Back, lumbar and limb pain	23 (13.8)	35 (14.4)	58 (14.1)
Dyspnea, cough and chest pain	23 (13.8)	31 (12.8)	54 (13.2)
Trauma	21 (12.6)	26 (10.7)	47 (11.5)
Abdominal pain	11 (6.6)	22 (9.1)	33 (8.0)
Eye diseases	12 (7.2)	17 (7)	29 (7.1)
Neck pain, headache and facial pain	5 (3)	22 (9.1)	27 (6.6)
Dizziness, palpitations and syncope	14 (8.4)	9 (3.7)	23 (5.6)
Skin and mucous membrane lesions	2 (1.2)	16 (6.6)	18 (4.4)
Neurological impairment and neurological focus	7 (4.2)	6 (2.5)	13 (3.2)
Fever	7 (4.2)	10 (4.1)	17 (4.1)
Hemorrhage, thrombosis and anemia	4 (2.4)	13 (5.3)	17 (4.1)
Urological disorder	12 (7.2)	4 (1.6)	16 (3.9)
Others	8 (4.8)	5 (2.1)	13 (3.2)
ENT disease	6 (3.6)	7 (2.9)	13 (3.2)
Vomiting and intestinal disorders	5 (3)	12 (4.9)	17 (4.1)
Psychiatric disorder	3 (1.8)	6 (2.5)	9 (2.2)
Hypertension, edema and renal pathology	4 (2.4)	2 (0.8)	6 (1.5)
Total	**167 (40.7)**	**243 (59.3)**	**410 (100)**

SD: standard deviation.

Table 2. Descriptive statistics (frequency, percentage, mean and standard deviation) of variable resources, destination, time in hospital emergency department (ED), over-triage, under-triage, sensitivity and specificity

	ESI level by panel of expert				
	1	2	3	4	5
Number of resources [n (%)]					
0	–	4 (6.6)	5 (3.4)	12 (8.6)	36 (73.5)
1	–	5 (8.2)	17 (11.6)	115 (82.1)	8 (16.3)
More than 1	3 (100)	52 (85.2)	125 (85)	13 (9.3)	5 (10.2)
Destination [n (%)]					
Discharge home	1 (33.3)	22 (36.1)	131 (85.5)	139 (99.3)	47 (97.9)
Hospitalization	2 (66.7)	39 (63.9)	17 (11.5)	1 (0.7)	1 (2.1)
Duration of ED stay [mean (SD)]	476 (228)	716 (659)	333 (259)	176 (110)	166 (93)
Over-triage [n (%)]	–	–	4 (2.7)	22 (15.2)	13 (25)
Under-triage [n (%)]	–	9 (14.75)	15 (10)	1 (0.69)	–
Sensitivity %	100	85.2	87.3	84.01	75.02
Specificity %	100	87.1	88.7	86.2	80

ED: hospital emergency department; ESI: Emergency Severity Index; SD: standard deviation.

similarity with the informal classification scheme that traditionally had been used for years in the ED. Secondly, the plasticity and the simplicity of its sole algorithm, which facilitates training and its practical application. And thirdly, the ease with which the triage forms can be introduced in the medical history computer files of the hospital, in spite of the lack of computer support for ESI, which may seem like a disadvantage today compared to other scales triage[25,26].

When applying triage to real patients, it is necessary to establish a baseline, a gold standard. This was achieved by a system of double triage in which an independent expert and a triage nurse carried out the same assessment consecutively and independently. This technique was taken and modified from that used by Gómez Jiménez et al. for their validation of the Andorran triage model[25]. The overall sensitivity, specificity, overtriage and undertriage values obtained can be considered acceptable and are in line with those previously reported by other authors working with ESI[21], 27 and other systems[20,28].

The results of interobserver agreement (both weighted and unweighted) of the double triage system were good or very good, confirming the reliability of the tool (Table 3). However, this study also aimed to assess the experts who were used as the gold standard in the double triage. For that purpose a new expert group was created. This group reviewed the triage cases database and reached an ESI level consensus that helped evaluate agreement between the nurses and the initial experts. This analysis, seldom reviewed in publications about validation of triage systems should be considered essential for obtaining evidence of content and consensus validity[10,22].

Remarkably, ESI level 1 was scarce in the sample. This may hinder the generalisation of the results. Level

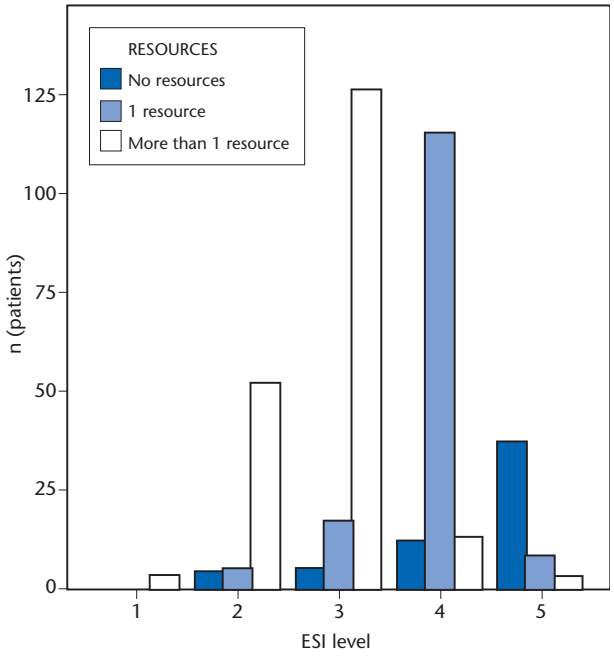

Figure 1. Resources used in accordance with the Emergency Severity Index (ESI) algorithm.

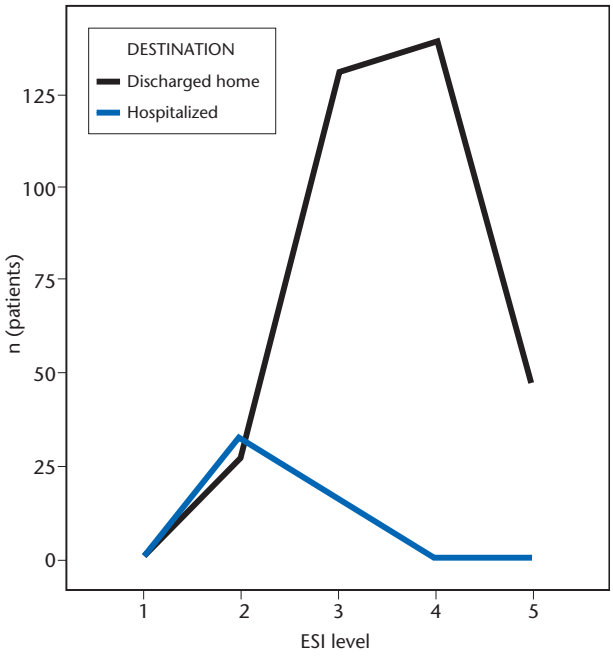

Figure 2. Patients discharged and admitted according to Emergency Severity Index (ESI) level.

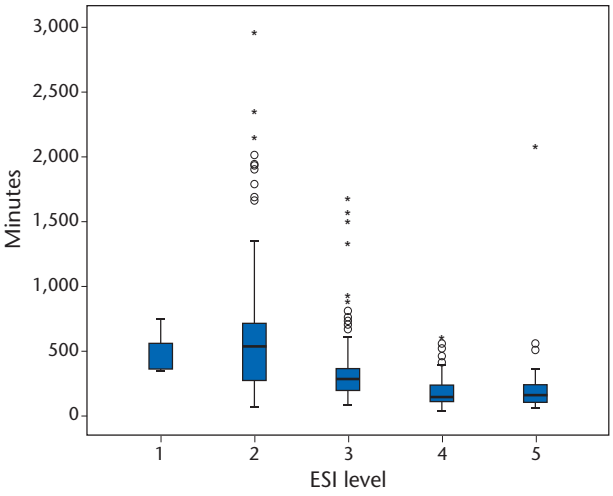

Figure 3. Time in minutes spent in the hospital emergency department according to Emergency Severity Index (ESI) triage. Box plots show median, interquartile range, maximum and minimum values and atypical values (circles) or outliers (asterisks).

1 patients require immediate life-sustaining treatment, are almost always transported to EDs by emergency services and obviously bypass conventional triage. This deficiency has been reflected by various authors[14,27].

The next logical step was to ask whether these results obtained with ESI triage in the medical environment of the study correlated with specific patient outcomes, that is, if predictive validity of the triage decisions taken could be inferred. Previous studies conducted in the United States highlighted the relationship between the level of urgency, expressed as ESI triage level, and the percentage of admissions[11,12,14]. Our results follow a similar pattern, albeit with lower admission figures in categories 2, 3 and 4 (Table 2). This pattern was also described by Elshove-Bolk et al. in the Netherlands involving a sample of patients visiting the ED on their own initiative. The authors recorded admission rates of 56%, 13%, 2% and 1% for levels 2 to 5 respectively[15]. This coincidence of results may be due to the similarity of samples in terms of severity of the patients.

Both the length of stay in the ED and the consumption of resources are defined as good predictors of ED patient complexity[29]. In our study, the length of stay in the ED increased with the level of urgency (Table 2), except for level 1, whose length of stay was shorter than that of level 2 (Figure 3). This phenomenon has been described for ESI[16,25,30] and other systems[25] by different authors. On the other hand, if the patient is correctly classified according to their level of urgency, the higher the level, the greater the consumption of resources. In this regard and in accordance with previous studies, consumption of resources and the ESI level showed a strong association (Figure 1)[11,14-16].

Mortality is a key indicator and a fundamental validation factor, but mortality data could not be collected for different reasons. The most important one was the nature of the study itself, which is not a population study, but an experience to gather evidence of the validity and safety guarantees of a training plan so as to initiate its implementation. Thus, once the system is implemented, new analysis on larger population samples will be needed. At that time mortality will be analysed, and the final validation of the ESI system will be carried out.

In conclusion, this work found evidence of the validity of a pilot ESI triage system in the ED of a general hospital.

Conflict of interest

The authors declare that they have no conflict of interest related to this article.

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Tabla 3. Frequency, percentage, kappa and intra-class correlation coefficient (ICC) of the observations of phase III

Comparison	Kappa index (95%) CI (p value)	
	Unweighted	Weighted quadratic
Nurse versus medical expert	0.68 (0.651; 0.717) (p < 0.001)	0.81 (0.67; 0.94) (p < 0.001)
Nurse versus panel of experts	0.77 (073; 0.83) (p < 0.001)	0.86 (0.73; 0.98) (p < 0.001)
Medical expert versus expert panel	0.85 (0.81; 0.90) (p < 0.001)	0.88 (0.75; 0.99) (p < 0.001)

CI: confidence interval.

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