Validity of the Emergency Severity Index in a Finnish Emergency Department

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Original research

Keywords: Triage, Emergency Severity Index, Geriatric, Emergency Department, Older adults, acuity assessment

DOI: https://doi.org/10.21203/rs.3.rs-320789/v1

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Abstract

Background: The purpose of acuity assessment, triage, in the emergency department is to recognize critically ill patients and to allocate resources. The Emergency Severity Index (ESI) is used widely around the world and has been shown to be at least as good as other 5-level assessment instruments. In this study, we assess validity of the ESI triage system in a Finnish Emergency department for predicting 30-day mortality as primary outcome and hospital admissions, high dependency unit or intensive care unit admissions as secondary outcomes, and efficiency for predicting emergency department length-of-stay and utilized resources as secondary outcomes.

Methods: We collected data of all adult patient visits to the emergency department during a one-month period. The data was analyzed for the primary and secondary outcomes stratified by age: younger adults (18-64 years), older adults (65-79 years) and oldest old (>80 years).

Results: Of the 5909 visits, 5511 were eligible for analysis, 2725 of them men. Median age was 59 years; 30-day mortality was 150 (2.7%). In all age groups, 30-day mortality was consecutively higher with statistical significance between each step from between categories 1 to 3. There were 2274 admissions, 190 of theo ICU admissions rates were significantly higher between each step between categories 2 to 4 for all adults. HDU/ICU admissions were higher in category two than in category three in all age groups. Resource utilization was higher in category three than in category four. Categories 4 and 5 differed only in the younger adult group. Most patients in categories four and five required ≥2 and 0 resource, respectively. Median length of stay at the emergency department was 3h 47min. For all patients ED-LOS varied without linearity; LOS was longest in category three in all age groups.

Conclusions: ESI seems to be a valid tool for acuity assessment in all age groups in our population: it recognized severely ill patients by predicting mortality and hospital admissions in the higher triage categories in all age groups. Having failed to predict both resource consumption and ED-LOS, ESI was not associated with efficiency in our population.

Background

Assessment of acuity in the emergency department, triage, is to recognize critically ill patients that are in urgent need of treatment, and to allocate resources according to need improving efficiency and safety(1). Evidence regarding instruments for acuity assessment improving patient outcomes is limited (2).

There is no golden standard for validating triage instruments. Previous studies have been observational, and validation has been based on mortality, hospital admission and ICU admission between triage categories (3). Efficiency has usually been assessed based on emergency department (ED) length-of-stay and the need of resource allocation in the ED. Resources include imaging, blood and urine samples, electrocardiograms (ECG), need for intravenous fluid or parenteral medication. (4–9)

In a recent systematic review, the Emergency Severity Index (ESI) seemed to be at least as good as the also commonly used Canadian Triage Acuity Scale and the Manchester Triage Scale (10, 11). To our current knowledge, no previous studies of predictive abilities of the ESI triage have been published in Northern Europe. The ESI algorithm is presented in Appendix 1

In this study, we assess validity and accuracy of the ESI triage system in a Finnish ED. Primary outcome is 30-day mortality and secondary outcomes are admission to hospital, high dependency unit (HDU) or intensive care unit (ICU), ED length-of-stay, and required resources in the ED.

Methods

Prior collecting data, we obtained a permission from the ethical board of University of Helsinki (HUS/2678/2017), the Helsinki University hospital (HUS/280/2019), and Tampere University Hospital (RI8602). Data was collected retrospectively from a database in Tampere University hospital, a large ED with 100,000 annual visits. ESI has been used in the ED since 2007 and is locally well established. We selected the data to be collected in the month of February, which has high occurrence for both trauma and infections, due to the Nordic weather conditions.

Data collection

We obtained data of all adult ED visits that included every adult patient in the ED between February the 1st and 28th in 2018. Pediatric patients and patients who were dead on arrival were excluded. Also excluded were patients who were not seen by a physician, but a registered nurse, as those patient visits were not assessed by ESI.

For each visit, we collected the following data: date of birth, gender, time and date of arrival and departure, date of death (if within 30 days from visit), triage category, hospital and ICU admission, imaging, blood and urine tests and ECG’s. We also collected procedures that were recorded in a structured report; these include only procedures requiring sedation or anesthesia. Resources were pooled into a variable in the following way: 1 point for blood test, 1 point for urine test, 1 point for ECG, 1 point for a recorded procedure, 1 point for an arterial blood gas test, 1 point for each imaging modality.

Analysis

Data was analyzed with the Statistical Package for the Social Sciences (SPSS) program. Adjusted difference between each triage category were tested. The Fisher exact test was used for binary outcomes, and the Mann-Whitney U test was used for nonparametric outcomes. P-values were corrected by using the Bonferroni method. The analysis was stratified by age groups: 18–64 years, 65–79 years, and 80 + years. Resource consumption was divided into three groups according to the ESI-algorithm: 0, 1, and ≥ 2.

Results
We included 5511 visits to the study after excluding 36 visits of dead-on-arrival patients, and 354 visits of patients who were seen by a nurse and not assessed according to ESI. Median age was 59 years (range 18–104). There were 3141 younger adult (age 18–64 years) visits, 1337 older adult (age 65–79 years) visits and 1033 visits from oldest old (age ≥ 80). Of the included patient visits, 2725 were men and 3184 were women. Overall Mortality in 30-day follow-up was 150/5511 (2.7%). 2274 patients were admitted to the hospital, 190 of whom to an HDU/ICU. Median length-of-stay at the ED was 3 hours 47 minutes. Detailed demographics are described in Table 1.

### Table 1

| Patient characteristics | All (n = 5511) | 18–64 (n = 3141) | 65–79 (n = 1337) | >=80 (n = 1033) |
|-------------------------|---------------|-----------------|-----------------|----------------|
| Age (median)            | 59            | 41              | 72              | 86            |
| Male                    | 2725 (49.4%)  | 1506 (47.5%)    | 681 (50.9%)     | 371 (35.9%)   |
| 30-day mortality        | 150 (2.7%)    | 31 (1.0%)       | 41 (3.1%)       | 78 (7.6%)     |
| Admitted to hospital    | 2274 (41.3%)  | 859 (27.3%)     | 706 (52.8%)     | 706 (68.3%)   |
| Admission to HDU/ICU    | 190 (3.4%)    | 89 (2.8%)       | 66 (4.9%)       | 35 (3.4%)     |
| Median Length-of-stay (min) | 227          | 208             | 244             | 300           |
| Allocated to ESI 1      | 16 (0.3%)     | 8 (0.3%)        | 4 (0.3%)        | 4 (0.4%)      |
| Allocated to ESI 2      | 541 (9.8%)    | 262 (8.3%)      | 159 (11.9%)     | 120 (11.6%)   |
| Allocated to ESI 3      | 4041 (73.3%)  | 2142 (68.2%)    | 1051 (78.6%)    | 848 (82.1%)   |
| Allocated to ESI 4      | 801 (14.5%)   | 634 (20.2%)     | 113 (8.5%)      | 54 (5.2%)     |
| Allocated to ESI 5      | 112 (2.0%)    | 95 (3.0%)       | 10 (0.7%)       | 7 (0.7%)      |

Mortality

Mortality rate and Bonferroni-corrected p-values for all between category comparisons for all age groups are presented in Table 2 and illustrated in Fig. 1.1. For all adults, 30-day mortality was consecutively higher with statistical significance between each step from category 3 to category 1 in all age groups.
Table 2

| ESI triage category  | Age group | Mortality rate | P-values (corrected with the Bonferroni method) |
|----------------------|-----------|----------------|------------------------------------------------|
| 1 18–64              | 4/8 (50.0%) | 0.003          |                                                |
| 65–79                | 3/4 (75.0%) | 0.027          |                                                |
| > 80                 | 4/4 (100.0%) | 0.011          |                                                |
| total                | 11/16 (68.8%) | < 0.001       |                                                |
| 2 18–64              | 10/262 (3.8%) | < 0.001        | 0.005                                          |
| 65–79                | 13/159 (8.2%) | 0.005          | 0.008                                          |
| > 80                 | 22/120 (18.3%) | 0.001          | 0.002                                          |
| total                | 45/541 (8.3%) | < 0.001        | < 0.001                                        |
| 3 18–64              | 13/2142 (0.6%) | 10.000          |                                                |
| 65–79                | 25/1051 (2.4%) | 1.460          |                                                |
| > 80                 | 52/848 (6.1%) | 0.468          |                                                |
| total                | 90/4041 (2.2%) | 0.001          |                                                |
| 4 18–64              | 3/634 (0.5%) | 4.286          |                                                |
| 65–79                | 0/113 (0.0%) | n/a            |                                                |
| > 80                 | 0/54 (0.0%) | n/a            |                                                |
| total                | 3/801 (0.4%) | 4.081          |                                                |
| 5 18–64              | 1/95 (1.1%) | 21.786         |                                                |
| 65–79                | 0/10 (0.0%) | n/a            |                                                |
| > 80                 | 0/7 (0.0%) | n/a            |                                                |
| total                | 1/111 (0.9%) | 21.786         |                                                |

| Hospital admission figures by age group and triage category with Bonferroni-corrected p-value table for between-group comparisons are presented in Table 2 and illustrated in Fig. 1.2. Admission rates were significantly higher in more urgent categories between triage categories 2 to 4 in all age groups. There was no significant difference between categories 1 and 2 or 4 and 5. |

Figure 1: 30-day mortality rates (1.1.) and hospital admissions (1.2) in each triage category stratified by age

Admission to ICU /HDU

Figures for admission to HDU/ICU stratified by age and triage category with between category comparisons for all age groups are presented in Table 3 and illustrated in Fig. 2.1 For all patients, HDU/ICU admission was consecutively more likely with statistical significance between each step from category 4 to category 2.

Figure 2: HDU/ICU admission rates (2.1) and ED-LOS (2.2) by triage category and age

Resource utilization

Figures for resource utilization by age group and triage category are presented in Table 3. For all patients, resource utilization was consecutively higher with statistical significance between each step from category 5 to category 2. Stratified by age, asignificant difference was not found in the older and oldest adult groups. Specifically, 196/801 (24.5%) patients in triage category 4 required exactly one resource and 81/112 (72.3%) of patients in triage category 5 required no resources.
Older patients in category 4 required 0, 1 or ≥ 2 resources equally often; same applied to the oldest patients in both categories 4 and 5.

Table 3
HDU / ICU admision and differences in resource consumption by age group and triage category

| ESI Triage category | 2 | 3 | 4 | 5 | xxx | ESI Triage category | 2 | 3 | 4 |
|---------------------|---|---|---|---|-----|---------------------|---|---|---|
| Age group           |   |   |   |   |     | Age group           |   |   |   |
| HDU/ICU admissions  |   |   |   |   |     | Required resources  |   |   |   |
| P-values (corrected with the Bonferroni method) |   |   |   |   |     | P-values (corrected with the Bonferroni method) |   |   |   |
| 1 18–64 5/8 (62.5%) | 0.091 | < | 0.001 | 1 18–64 3,231 0.842 |
| 65–79 1/3 (33.3%) | 10.000 | 0.477 | 65–79 5,992 5,692 |
| > 80 1/4 (25.0%) | 9.000 | 0.417 | > 80 5,099 4,792 |
| total 7/15 (46.7%) | 0.564 | < | 0.001 | total 7,092 3,391 |
| 2 18–64 50/262 (19.1%) | < | 0.001 | < | 0.001 | 2 18–64 6,744 6,744 |
| 65–79 47/156 (30.1%) | < | 0.003 | < | 0.001 | 65–79 8,774 < 0.001 |
| > 80 25/116 (21.6%) | < | 0.001 | < | 0.001 | > 80 8,718 < 0.001 |
| total 122/534 (22.8%) | < | 0.001 | < | 0.001 | total 0.006 < 0.001 |
| 3 18–64 34/2141 (1.6%) | 0.002 | 3.592 | 3 18–64 0.001 < 0.001 |
| 65–79 16/1051 (1.5%) | 6.915 | 10.000 | 65–79 6,774 < 0.001 |
| > 80 9/846 (1.1%) | 9.000 | 9.000 | > 80 6,718 < 0.001 |
| total 59/4038 (1.5%) | 0.026 | 4.091 | total 0.006 < 0.001 |
| 4 18–64 0/634 (0.0%) | n/a |     |     | 4 18–64 349/634 (55%) 145/634 (22.9%) 140/634 (22.1%) |
| 65–79 2/113 (1.8%) | 10.000 |     |     | 65–79 43/113 (38.1%) 31/113 (34.5%) 15/113 (27.8%) |
| > 80 0/54 (0.0%) | n/a |     |     | > 80 15/54 (27.8%) 20/54 (37.0%) 19/54 (35.2%) |
| total 2/801 (0.2%) | 10.000 |     |     | total 407/801 (50.8%) 196/801 (24.5%) 198/801 (24.7%) |
| 5 18–64 0/95 (0.0%) |     |     |     | 5 18–64 73/95 (76.8%) 9/95 (9.5%) 13/95 (13.7%) |
| 65–79 0/10 (0.0%) |     |     |     | 65–79 6/10 (60.0%) 1/10 (10.0%) 3/10 (30.0%) |
| > 80 0/7 (0.0%) |     |     |     | > 80 2/7 (28.6%) 2/7 (28.6%) 3/7 (42.9%) |
| total 0/112 (0.0%) |     |     |     | total 81/102 (72.3%) 12/102 (10.7%) 19/102 (17.0%) |

ED-LOS
Figures for ED-LOS with between-category comparisons for all age groups are presented in Appendix 2 and illustrated in Fig. 2.2. For all patients ED-LOS varied without linearity. In all age groups, LOS was longest in triage category 3.

Strengths and Limitations

Although this was a single center study, the number of included patients was relatively large. All age groups were well represented. The number of patients in triage categories 1 and 5 were relatively small, due to which we were unable to complete some comparisons. The number of male patients in the oldest adult group was lower, which reflects the general gender distribution in the older adults in Finland (36% male).
Our data from the electronic health record is comprehensive for all other outcomes except resource utilization. Bedside procedures such as fracture immobilization or bedside ultrasound are recorded only in plain text and could not be collected automatically with the rest of the data. This applied to all triage categories and age groups alike.

**Discussion**

ESI has previously been shown to predict mortality in the ED (12) and in-hospital mortality (11, 13, 14), which is in keeping with our finding of associated 30-day mortality. Our hospital admission as well as HDU/ICU admission results for all adults are in keeping with previous studies (5, 11, 13). For older adults, our hospital and HDU/ICU admission results are also in keeping with previous studies. (7, 12, 15, 16).

Contrary to previous studies for all adults (16, 17) and for older adults (7, 15), our study suggests that ESI predicts resource consumption modestly in the younger adult group and poorly in the older and oldest adult groups. This might be due to a difference in methodology: previous studies have shown a relationship with increasing resource consumption and triage level, whereas we aimed to investigate whether ESI could deliver the prediction of resource consumption between none, one or many.

According to our results, ESI did not predict ED-LOS in any age group, which is in contrast to previous findings (7, 11, 16, 17). We hypothesize that this is due to exit block – sicker patients moved quickly to HDU/ICU beds and ambulatory patients were discharged, leaving standard urgency patients in category 3 to wait for beds in the ED.

**Conclusions**

ESI seems to be was a valid tool for acuity assessment in all age groups in our population: it recognized severely ill patients by predicting mortality and hospital admissions in the higher triage categories in all age groups. Having failed to predict both resource consumption and ED-LOS, ESI was not associated with efficiency in our population.

**Declarations**

**Ethics approval and consent to participate**

The study protocol and data collecting were approved by the Ethics Committee of the Helsinki University Hospital (reference number HUS/2678/2017). Data collection was approved by the Helsinki University Hospital (reference number HUS/280/2019) and Tampere University Hospital (reference number RI8602). The ethical board did not require obtaining consent from patients for this observational study.

**Consent for publication**

N/A

**Availability of data and materials**

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

**Competing interests**

The authors declare no competing interests.

**Funding**

The study was funded with state funding for university-level health research from Helsinki University Hospital (funding for KK salaries during the preparation, data collection and analysis, funding for supporting personnel salaries and minor miscellaneous expenses) and funding from Emergency Medicine, University of Helsinki and Department of Emergency Medicine and Services, Helsinki University Hospital (funding for KK salaries during the preparation, data collection and analysis and the open access publication fee). Author KK has received grants the Finnish Association for Emergency Medicine as compensation for study expenses (reduced salary during the research period, expenses due to publishing and reporting).

**Authors’ contributions**

Study concept and design (KK, JA, MK, ML, LL, MC), acquisition of the data (KK, MK), analysis and interpretation of the data (KK, JA, ML), drafting of the manuscript (KK, JA), critical revision of the manuscript for important intellectual content (KK, JA, MK, ML, LL, MC), statistical expertise (KK, JA, ML) and acquisition of funding (LL, MC). All authors read and approved the final manuscript.

**Acknowledgements**

Steve Kemp (language editing)

Sami Mustajoki (acquisition of the data)

**Abbreviations**
ECG  Electrocardiogram
ED Emergency Department
ESI Emergency Severity Index
HDU High Dependency Unit
ICU Intensive Care Unit
LOS Length of Stay
SPSS Statistical Package for the Social Sciences

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Appendix 1: The ESI Triage Algorithm

Fig 3: The ESI triage algorithm

Originally published in Emergency Severity Index, Version 4: Implementation Handbook (18), © ESI Triage Research Team.

Appendix 2: ED-LOS Comparisons
| ESI Triage category | 2 | 3 | 4 | 5 |
|---------------------|---|---|---|---|
| **Age group**       | ED-LOS (median IQR) /min | P-values (corrected with the Bonferroni method) |
| 1 18-64             | 81 (65-142) | 0.650 | 0.083 |
| 65-79               | 115 (104-122) | 0.777 | 0.020 |
| >80                 | 184 (108-266) | 3.327 | 0.599 |
| Total               | 105 (71-160) | 0.098 | <0.001 |
| 2 18-64             | 199 (128-302) | <0.001 | <0.001 |
| 65-79               | 212 (120-332) | <0.001 | 0.107 |
| >80                 | 244 (164-340) | <0.001 | 0.461 |
| Total               | 211 (132-321) | <0.001 | <0.001 |
| 3 18-64             | 239 (157-338) | <0.001 | <0.001 |
| 65-79               | 285 (207-392) | <0.001 | 0.001 |
| >80                 | 317 (229-425) | <0.001 | 0.947 |
| Total               | 266 (185-374) | <0.001 | <0.001 |
| 4 18-64             | 139 (86-209) | 0.031 |
| 65-79               | 171 (109-230) | 2.272 |
| >80                 | 175 (116-296) | 8.741 |
| Total               | 147 (88-215) | 0.016 |
| 5 18-64             | 107 (58-196) | |
| 65-79               | 130 (79-201) | |
| >80                 | 210 (111-334) | |
| Total               | 112 (60-199) | |

Fig 4: The ED LOS comparisons

**Figures**

![Fig 1.1](image1)

![Fig 1.2](image2)

**Figure 1**

30-day mortality rates (1.1) and hospital admissions (1.2) in each triage category stratified by age
Figure 2

HDU/ICU admission rates (2.1) and ED-LOS (2.2) by triage category and age

Figure 3

The ESI triage algorithm