Archives of Academic Emergency Medicine. 2023; 11(1): e57

ORIGINAL RESEARCH

Associated Factors of Under and Over-Triage Based on The Emergency Severity Index; a Retrospective Cross-Sectional Study

Thongpitak Huabbangyang[1], Rapeeporn Rojsaengroeng[2]*, Gawin Tiyawat[1], Agasak Silakoon[1], Alissara Vanichkulbodee[2], Jiraporn Sri-on[2], Siriwimol Buathong[3]

1. Department of Disaster and Emergency Medical Operation, Faculty of Science and Health Technology, Navamindradhiraj University, Bangkok, Thailand.

2. Department of Emergency Medicine, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand.

3. Phetchabun Hospital, Phetchabun Province, Thailand

Received: June 2023; Accepted: July 2023; Published online: 21 August 2023

Abstract: **Introduction:** Under-triage increases patients' risks for morbidity and mortality, whereas over-triage limits the resources available to sicker patients. This study aimed to determine the rates as well as associated factors of under-triage and over-triage in emergency department (ED), based on Emergency Severity Index (ESI) triage system. **Methods:** In this retrospective cross-sectional study, triage level of ED patients based on the ESI version 4, was studied during a 9-month period in 2019. Patients' ESI level, which were examined by triage nurses were reevaluated by 3 emergency physicians and the rate of correct, under-, and over-triage as well as their associated factors were analyzed. **Results:** 1000 cases of triage were evaluated. Triage was correct in 69.1% of cases. The rate of under-triage was 4.9%, and that of over-triage was 26.0%. Over-triage was significantly more common among patients aged 18–30 years than for those aged ≥65 years (adjusted odds ratio [OR] = 1.73; 95% confidence interval [CI]: 1.07–2.81; p = 0.026); those with traumatic injuries (adjusted OR = 1.80; 95% CI: 1.29–2.52; p = 0.001); those arriving at the hospital during the evening shift (adjusted OR = 1.42; 95% CI: 1.01–2.0; p = 0.046); patients who were hospitalized (adjusted OR = 0.35; 95% CI: 0.22–0.54; p < 0.001); and those with severe pain (adjusted OR = 0.28; 95% CI: 0.10–0.84; p = 0.023). Younger age was also significantly associated with under-triage. Patients aged 18–30 years were under-triaged more often than those aged ≥65 years (adjusted OR = 3.05; 95% CI: 1.16–8.00; p = 0.023). **Conclusion:** Over-triage was substantially more common than under-triage in Vajira Hospital. Factors associated with over-triage were younger age, traumatic injury, arrival time, hospital admission, and severe pain. Younger age was the only factor related to under-triage.

Keywords: Emergency service, hospital; Triage; Emergency medicine; Nurses; Physician-nurse relations

Cite this article as: Huabbangyang T, Rojsaengroeng R, Tiyawat G, Silakoon A, Vanichkulbodee A, Sri-on J, Buathong S. Associated Factors of Under and Over-Triage Based on The Emergency Severity Index; a Retrospective Cross-Sectional Study. Arch Acad Emerg Med. 2023; 11(1): e57. https://doi.org/10.22037/aaem.v11i1.2076.

1. Introduction

Triage is a main task in emergency departments (EDs), performed to identify and clinically prioritize patients who have life-threatening conditions and require urgent medical service over patients with no severe conditions who are able to wait for an examination (1, 2).

The ED functions around the clock, and many patients arrive without an appointment; queues are not used to prioritize examination and treatment (3). The numbers of patients treated at EDs are likely to rise, because increasing numbers of patients have progressive diseases and are injured in accidents; however, the numbers of medical personnel and resources are typically limited, even in industrialized countries. According to research evidence, correct levels of triage help ameliorate this issue and reduce disability and mortality rates significantly (4).

A recent systematic review of current and popular triage patterns in EDs revealed that these patterns are based on many measures, such as the Australian Triage Scale, Canadian Emergency Department Triage and Acuity Scale, Manchester

*Corresponding Author: Rapeeporn Rojsaengroeng; Department of Emergency Medicine, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand. Tel: +66 2-244-3000, Email: rapeeporn@nmu.ac.th, ORCID: https://orcid.org/0000-0002-7365-3948.

Triage Scale, Emergency Severity Index (ESI), Soterion Rapid Triage Scale, and Taiwan Triage System (2). The five-level ESI is currently the most popular measure for determining triage; it is used extensively worldwide, including in industrialized countries such as the United States (5), and in Thailand. According to the National Institute for Emergency Medicine in Thailand, EDs nationwide use version 4 of the ESI. In this system, developed in 1999 in the United States, disease severity and the number of resources needed for treatment are evaluated to determine urgency. Use of this screening system requires experience and expertise in triage. The task of initial triage is performed by triage nurses based on the ESI in the ED (6, 7). According to a previous study, the knowledge and skills of triage nurses affected the accuracy of triage; therefore, specialized training might help increase the accuracy of triage and decrease rates of over-triage and under-triage (8). A previous large study of EDs in England revealed that triage was correct in 67.8% of cases, over-triage in 28.9%, and under-triage in 3.3%. Another study showed that over-triage was more common for black patients than for white patients, children were at higher risk for over-triage than were adults, and patients who used high-risk medications were at increased risk for under-triage (9). In EDs in Brazil, the rate of over-triage in high-acuity cases (ESI level 1 or 2) was 8.7%, and in cases of moderate acuity (ESI level 3) it was 13.6%; the rate of under-triage among high-acuity cases was 5.8%, and for low-acuity cases (ESI level 4 or 5) it was 18.4% (10). In an ED in Thailand, the accuracy of triage according to ESI, performed by nurses, was 52.4% (11). In a large observational study of EDs in Thailand in 2016, the rate of under-triage was 34.71%, and that of over-triage was 28.35% (12).

In Thailand, accurate triage for patients presenting with diseases and those injured in accidents is challenging for triage nurses. The purposes of this study were to examine rate of under-triage and over-triage in an ED in Thailand and to clarify factors leading to under-triage and over-triage. The findings could help improve triage according to the ESI and help clinicians monitor risk factors for mistriage.

2. Methods

2.1. Study design and setting

This retrospective, single-center, cross-sectional study was conducted in the ED of Vajira Hospital, Navamindradhiraj University, a large tertiary care hospital in Bangkok, Thailand. Approximately 500,000 patients visit this ED every year (13). Triage is based on version 4 of the ESI (6). Nurses who perform initial triage have >5 years of working experience and had previous training in triage according to the ESI. To maintain knowledge and skills, they annually undergo further training in triage according to the ESI. This study was conducted according to the Standards for the Reporting of Observation Studies in Epidemiology (STROBE) statement (14) and the tenets of the 1975 Declaration of Helsinki and its revisions in 2000. It was approved by the Institutional Review Board of the Faculty of Medicine Vajira Hospital, Navamindradhiraj University (COA no. 93/2561), Amendment 4/2023. The informed consent requirement was waived because of the retrospective nature of the study and because all patient data were anonymized.

2.2. Participants

The medical charts of patients who visited the ED between 1 January and 31 December 2019 were reviewed retrospectively. Data were used if patients were older than 18 years, if triage was performed by triage nurses according to the ESI, if triage levels were documented in medical records, and if the data could be searched in and extracted from the electronic medical record system of the hospital. Patients with incomplete or missing data were not included.

2.3. Data gathering

In this study, triage accuracy was evaluated by two emergency physicians (EPs) to finalize the triage decision. Before the data were collected, interrater reliability was verified by a patient triage test. The accepted error coefficient was 20%, and the interrater reliability was analyzed using Fleiss's kappa. The principal investigator (TH) randomly chose 40 medical records for the two EPs (RR and GT) to compare triaging, which showed a kappa coefficient of 0.887. In a previous study, the kappa coefficient ranged from 0.81 to 1.00 (15). If the two EPs disagreed about triage, a third EP (AV) was consulted to finalize triage. The principal investigator used Microsoft Excel to record all data, which included gender, age, comorbidities, chief complaint (injury or illness), method of transportation to ED, arrival time, chief complaints, hospital admission, critical outcomes, systolic blood pressure, diastolic blood pressure, heart rate, respiratory rate, oxygen saturation, body temperature, pain severity (based on the visual analog scale [VAS]), Glasgow Coma Scale score, capillary blood glucose concentration, and triage level. To evaluate the accuracy of triage, the EPs examined each patient's treatment data: results of blood tests, urine tests, electrocardiography, and imaging studies; administration of intravenous fluids and intravenous, intramuscular, or nebulized medication; and specialist consultation. Each of these items counted as one resource. Vital signs were measured during triage, and the measurements were compared between those with correct triage and those with under-, and over-triage.

2.4. Outcome measures

The primary objective was to study the rates of under-triage and over-triage in the ED according to the ESI. The secondary

objective was to analyze factors related to under-triage and over-triage.

2.5. Definitions

"Correct triage" was defined by a match between the triage level determined by nurses and that determined by the three EPs (9, 10).

"Under-triage" was defined as when the first triage level determined by nurses was lower than that determined later by the EPs (9, 10). "Over-triage" was defined as when the first triage level determined by nurses was higher than that determined later by the EPs (9, 10). Triage is divided into five levels according to version 4 of the ESI. ESI level 1 reflects a critical emergency, such as life-threatening injury or illness; unless respiratory, cardiovascular, or neurological systems are managed immediately, the patient has a high chance of mortality, the severity of the injury or illness can increase, or complications can happen abruptly. ESI level 2 reflects injury or severe illness that probably necessitates emergency treatment; without treatment, the injury or illness could become more severe or lead to complications, resulting in mortality or disability later. ESI level 3 reflects no severe injury or illness, for which treatment can be delayed; affected patients can commute to the ED by themselves, but if they do not receive treatment within a certain time, the severity of injury or illness could increase, or complications could occur. ESI level 4 reflects general sickness that is not an emergency, for which treatment can probably be delayed without increased severity of symptoms or later development of complications. ESI level 5 reflects the need for other public health services, which do not necessitate the use of resources (6).

The resource utilization checklist includes clinical laboratory studies; imaging studies; electrocardiographic monitoring; special studies; administration of fluids, parenteral medications, and intramuscular medications; and specialist consultations, as defined in the ESI handbook (6).

2.6. Sample size determination

To explore the rates of under-triage and over-triage in the ED with regard to ESI, sample size was estimated according to a formula for proportional value (16); = 0.05, and the proportional value in a referred population from a previous study was considered (10). The proportion of patients receiving under-triage and over-triage was 17% (proportional value = 16,426/96071 = 0.17); d was defined as 0.05, and the necessary sample size was therefore 217.

To determine which factors led to under-triage and over-triage with regard to ESI, multiple logistic regression analysis was used. The number of events per variable thus needed to be calculated (17), and the sample size needed to reflect a limited time period. According to a previous study (18), the number of events per variable could be decreased but not to fewer than 5, which meant that each predictive factor would have at least five studied outcome events. In this way, the sample size in this study could be reduced. A literature review revealed that 26 factors or variables were predictive of the level of triage selected, which reflected 130 outcome events; the rate of under-triage and over-triage in EDs was calculated to be 17% (10). Thus, to determine which factors led to under-triage and over-triage, the sample size needed in this study was $100 \times 130/17 = 746.70$. Because data were retrospectively collected from medical records, an additional 20% was calculated according to a sample size adjustment formula (nnew = 746.70/[1 - 0.20]), which yielded 933.38. Therefore, the sample size needed for this study was determined to be 1000. Sampling was performed in accordance with simple random sampling among patients visiting the ED between 1 January and 31 December 2019.

2.7. Statistical analysis

A descriptive analysis was performed to examine variable distribution. Values of continuous variables were calculated as means ± standard deviations or as medians and interquartile ranges (IQRs), and those of categorical variables were calculated as frequencies and proportions. In comparisons of two groups, differences were evaluated using independent t test or Mann–Whitney U test for continuous variables and using chi-square test or Fisher's exact test for categorical variables.

To determine factors associated with under-triage or over-triage, multinomial logistic regression analysis was performed. IBM SPSS Statistics for Windows, Version 28.0 (IBM Corporation, Armonk, NY, USA), was used. All statistical tests were considered statistically significant at a p level of 0.05.

3. Results

3.1. Baseliner characteristics of the sample

Of the 1000 participants triaged during the study period, 52.4% were male. The mean age was 47.94 ± 21.81 years, and the largest age group consisted of patients aged 18–30 years (29.5%). Comorbidities were present in 42.7%, and 33.4% had traumatic injuries. Most participants (91.5%) were walk-in patients, and 45.2% visited the hospital during the evening shift (4:00–11:59 pm). The most common chief complaint was trauma (in 25.4% of patients), followed by abdominal pain (9.9%) and fever (7.2%). The hospital admission rate was 28.7%, and 66.8% of hospitalized patients were discharged within 24 hours. Table 1 summarizes the baseline characteristics of studied cases.

3.2. Triage results

Among the triage levels determined initially, 4.3% were ESI 1, 21.7% were ESI 2, 59.1% were ESI 3, 12.9% were ESI 4, and 2%

were ESI 5. Among the triage levels determined by the EPs, 3.8% were ESI 1, 16.7% were ESI 2, 52.1% were ESI 3, 17.9% were ESI 4, and 9.5% were ESI 5. The triage level was correct in 69.1% of cases. The rate of under-triage was 4.9%, and that of over-triage was 26.0%.

3.3. Associated factors of over-triage and under-triage

Table 1 shows the results of univariate analysis. Over-triage was significantly more common among patients aged 18–30 years (OR = 2.19; 95% CI: 1.47–3.26; p < 0.001); patients with traumatic injuries (OR = 2.11, 95% CI: 1.57–2.83, p < 0.001); patients who were hospitalized (OR = 0.27, 95% CI: 0.18–0.41, p < 0.001); patients with abnormal respiratory rates (OR = 0.64, 95% CI: 0.44–0.92, p = 0.016); patients with <90% oxygen saturation (OR = 0.09, 95% CI: 0.01–0.66, p = 0.018); patients with severe pain (VAS score of 8–10) (VAS score of 0–7; OR = 0.23, 95% CI: 0.08–0.65, p = 0.006); and patients with a Glasgow Coma Scale score of <15 (OR = 0.30, 95% CI: 0.13–0.66, p = 0.003).

However, no factor was significantly associated with under-triage.

Based on multivariate analysis and when the influence of confounders was controlled, factors significantly associated with over-triage included age, chief complaint (injury or illness), arrival time, hospital admission, and pain severity. Patients aged 18–30 years were over-triaged more often than patients aged ≥65 years (adjusted OR = 1.73; 95% CI: 1.07–2.81; p = 0.026). Patients with traumatic injuries were over-triaged more often than those without such injuries (adjusted OR = 1.80, 95% CI: 1.29–2.52, p = 0.001). Patients who visited the hospital during the evening shift (4:00–11:59 pm) were over-triaged more often than those who visited during the morning shift (8.00 am to 3.59 pm; adjusted OR = 1.42, 95% CI: 1.01–2.00, p = 0.046). Patients who were eventually hospitalized were over-triaged more often than those who were not hospitalized (adjusted OR = 0.35, 95% CI: 0.22–0.54, p < 0.001), and patients with severe pain (VAS scores of 8–10) were over-triaged more often than those with mild or moderate pain (VAS scores of 0–7; adjusted OR = 0.28, 95% CI: 0.10–0.84, p = 0.023).

With regard to under-triage, age was a significant factor, when influence of confounders was controlled in analysis. Patients aged 18–30 years were under-triaged more often than those aged ≥65 years (adjusted OR = 3.05, 95% CI: 1.16–8.00, p = 0.023; Table 3).

4. Discussion

This study revealed that in the ED of a university hospital in Bangkok, Thailand, the rate of under-triage was 4.9% and that of over-triage was 26.0%, using version 4 of the ESI. These findings are consistent with those of a study of EDs in England, in which the rate of under-triage was 3.3% and that of over-triage was 28.9% (9), and comparable with those of a study in an ED in a tertiary hospital in Bangkok, in which the rate of correct triage was 68.7%, that of under-triage was 10.5%, and that of over-triage was 20.8% (19). However, these findings are not consistent with those of a previous large study of EDs in 15 hospitals operated by the Ministry of Health and Prevention of the United Arab Emirates, in which the rate of under-triage was 20.5% and that of over-triage was 79.5% (20). In 2014, the American College of Surgeons Committee on Trauma defined proper criteria for evaluating the severity of injury from accidents, which are considered international standards. In one study in which these standards were used, rates of under-triage and over-triage were determined to be 5% at most and 25%–35%, respectively (21). These recommended standards were followed in the ED in which this study was conducted.

The triage process is the first step in rendering health care. Quality assurance of triage in the ED in our study starts with the selection of triage nurses who have worked in the ED for >5 years. They need to pass training in triage according to version 4 of the ESI and to review knowledge about triage at least once a year. According to one study, the number of years of work as triage nurses in the ED was related to inaccuracy in determining the level of triage: nurses with <5 years of such experience were more likely to make errors in determining triage level (11). The number of hours spent in triage training was also significantly related to under-triage and over-triage (22). In the ED in this study, monthly triage quality assurance and case study review meetings could decrease rates of mis-triage, which would be consistent with the findings of a literature review, in which nurses in patient triage needed nursing review activities to maintain triage accuracy (23).

This study showed that five factors were associated with over-triage. First, patients aged 18–30 years were over-triaged more often than those aged ≥65 years. This finding was comparable with that in a previous study, in which over-triage usually occurred in patients aged ≥ 18 years (9), and was consistent with another study in this regard (10), in which patients aged 18–30 years were more likely than patients aged ≥65 years to be over-triaged for high-acuity conditions (ESI levels 1 and 2) and for moderate-acuity conditions (ESI level 3). This finding could be explained by the fact that the younger patients were at higher risk for injuries in traffic accidents and occupational accidents. Teenagers in this age group had complicated chief complaints similar to those in adults; moreover, injuries to their organs caused more radical physical and physiological changes, such as abdominal pain and dyspnea (24). For these reasons, triage nurses may have selected over-triage.

Second, patients with traumatic injuries were over-triaged

more often than those without such injuries. This finding was consistent with that of a previous study, in which the rate of over-triage for patients with traumatic injuries involving the chest or abdomen was as high as 87.50% (25). A possible explanation was that patients with traumatic injuries usually presented with complicated symptoms and required many laboratory tests. In addition, the EPs needed to consult specialists in other departments, such as surgeons, orthopedic surgeons, and plastic surgeons.

Third, patients visiting the ED during the evening shift (4:00–11:59 pm) were over-triaged more often than patients visiting during the morning shift (8.00 am–3.59 pm). This finding was comparable with that of a previous study (10). A possible explanation was that many hospital departments were closed during the evening shift, and the ED, which was therefore responsible for both emergency and non-emergency patients during the evening shift, became crowded. For non-emergency patients, laboratory tests and specialty consultation were required, but such resources were insufficient during the evening shift (26).

Fourth, hospitalized patients were over-triaged more often than non-hospitalized patients. This finding was consistent with that of a previous study of EDs in the United States, in which hospitalized patients were over-triaged 85% more often than non-hospitalized patients (9), and with that of a study in which hospitalized patients classified as having ESI levels 1 and 2 conditions were over-triaged more often than their non-hospitalized counterparts (25). Hospitalization was also identified as the reason why length of stay in the emergency department was ≥4 h (27). A possible explanation of this finding was that for most hospitalized patients, triage nurses usually assessed chief complaints, vital signs, and laboratory test results and consulted with specialists (27). Most admitted patients had comorbidities. Triage nurses might decide to over-triage such patients because they require dedicated management, special tests, pathological examinations, and radiological tests (28). Because triage nurses might anticipate whether patients' symptoms, comorbidities, and results of special tests indicate the need for hospital admission, they might be more likely to over-triage.

Fifth, patients with severe pain (VAS scores of 8–10) were over-triaged more often than patients with mild or moderate pain (VAS scores of 0–7). This finding was consistent with that of a previous study in which patients with severe pain were 79% more likely than those with less pain to be over-triaged (9, 10). VAS score might be considered abstract, and patients' pain scores might not represent the actual pain that they feel; for this reason, triage nurses may perform over-triage. The use of only a numerical scale of 1–10 to rate pain might result in more mistriage than would the additional use of pictures to rate pain (9).

With regard to under-triage, patients aged 18–30 years were under-triaged more often than patients aged ≥65 years. This finding was similar to that of a previous study (29) in which patients aged 18–30 years were under-triaged 78% more often than patients aged ≥65 years for high-acuity conditions (ESI level 1 or 2) and were more likely to be under-triaged for moderate-acuity conditions (ESI level 3). In that study, 34% of patients received under-triage. In another study, patients younger than 30 years were at higher risk for under-triage than were patients of other ages (30). In this study, patients aged 18–30 years were at higher risk for both over-triage and under-triage; therefore, triage nurses must be more careful in determining triage level for patients in this age range.

The results of this study imply that nurses should perform triage according to triage guidelines based on the ESI and should review triage criteria regularly. They should also be aware of factors associated with mistriage: age, chief complaint, arrival time, hospital admission, and pain severity.

5. Limitation

This study had many limitations. First, it was a single-center study in which data were collected from the ED of a university hospital in Bangkok, Thailand; therefore, the results might not apply to other areas, and the external validity of data may be poor. Second, the study was a retrospective review of medical records; although neutrality was maintained in every way possible, selection bias might have existed. Third, data were unavailable for multiple variables, including respiratory rate, oxygen saturation, body temperature, pain severity (VAS score) and capillary blood glucose concentration. Last, unmeasured confounding factors may have been present. The only measure used to triage was the ESI, and ESI levels 1–5 were not analyzed separately. In future studies, rates of and factors affecting under-triage and over-triage should be analyzed separately for the different ESI levels.

6. Conclusion

Over-triage occurs at a substantially higher rate than does under-triage. Five factors associated with over-triage were age, chief complaint (trauma or non-trauma), arrival time, hospital admission, and pain score, whereas age was the only factor related to under-triage.

7. Declarations

7.1. Acknowledgments

The authors are grateful to the Navamindradhiraj University Research Fund for Pub. We would like to thank all participating staff at ED, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, for facilitating data collection and access in the present study.

7.2. Conflict of interest

The authors have no conflicting interests to declare.

7.3. Funding and support

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

7.4. Authors' contribution

Conceptualization: Thongpitak Huabbangyang, Siriwimol Buathong and Rapeeporn Rojsaengroeng; Methodology: Thongpitak Huabbangyang, Siriwimol Buathong, Agasak Silakoon, Gawin Tiyawat, Alissara Vanichkulbodee, Jiraporn Srion and Rapeeporn Rojsaengroeng; Software: Thongpitak Huabbangyang; Validation: Thongpitak Huabbangyang and Rapeeporn Rojsaengroeng; Formal analysis: Thongpitak Huabbangyang; Investigation: Thongpitak Huabbangyang, Siriwimol Buathong and Rapeeporn Rojsaengroeng; Resources: Thongpitak Huabbangyang, Siriwimol Buathong and Rapeeporn Rojsaengroeng; Data Curation: Thongpitak Huabbangyang; Writing – Original Draft: Thongpitak Huabbangyang; Writing - Review & Editing: Thongpitak Huabbangyang and Rapeeporn Rojsaengroeng; Visualization: Thongpitak Huabbangyang and Rapeeporn Rojsaengroeng; Supervision: Thongpitak Huabbangyang; Project administration: Thongpitak Huabbangyang; Funding acquisition: Thongpitak Huabbangyang. All authors read and approved the final version of manuscript.

7.5. Data Availability

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

7.6. Using artificial intelligence chatbots

None.

References

1. Raita Y, Goto T, Faridi MK, Brown DF, Camargo CA, Hasegawa K. Emergency department triage prediction of clinical outcomes using machine learning models. Crit Care. 2019;23(1):64.
2. Farrohknia N, Castrén M, Ehrenberg A, Lind L, Oredsson S, Jonsson H, et al. Emergency department triage scales and their components: a systematic review of the scientific evidence. Scand J Trauma Resusc Emerg Med. 2011;19:42.
3. Fernandes M, Vieira SM, Leite F, Palos C, Finkelstein S, Sousa JM. Clinical decision support systems for triage in the emergency department using intelligent systems: a review. Artif Intell Med. 2020;102:101762.
4. af Ugglas B, Lindmarker P, Ekelund U, Djärv T, Holzmann MJ. Emergency department crowding and mortality in 14 Swedish emergency departments, a cohort study leveraging the Swedish Emergency Registry (SVAR). PloS one. 2021;16(3):e0247881.
5. Mistry B, De Ramirez SS, Kelen G, Schmitz PS, Balhara KS, Levin S, et al. Accuracy and reliability of emergency department triage using the emergency severity index: an international multicenter assessment. Ann Emerg Med. 2018;71(5):581-7. e3.
6. Gilboy N, Tanabe P, Travers DA, Rosenau AM, Eitel DR. Emergency severity index, version 4: implementation handbook. Rockville, MD: Agency for Healthcare Research and Quality; 2005.
7. Savatmongkorngul S, Yuksen C, Suwattanasilp C, Sawanyawisuth K, Sittichanbuncha Y. Is a mobile emergency severity index (ESI) triage better than the paper ESI? Intern Emerg Med. 2017;12:1273-7.
8. Jordi K, Grossmann F, Gaddis GM, Cignacco E, Denhaerynck K, Schwendimann R, et al. Nurses' accuracy and self-perceived ability using the Emergency Severity Index triage tool: a cross-sectional study in four Swiss hospitals. Scand J Trauma Resusc Emerg Med. 2015;23:62.
9. Sax DR, Warton EM, Mark DG, Vinson DR, Kene MV, Ballard DW, et al. Evaluation of the emergency severity index in US Emergency Departments for the rate of Mistriage. JAMA Netw Open. 2023;6(3):e233404.
10. Hinson JS, Martinez DA, Schmitz PS, Toerper M, Radu D, Scheulen J, et al. Accuracy of emergency department triage using the Emergency Severity Index and independent predictors of under-triage and over-triage in Brazil: a retrospective cohort analysis. Int J Emerg Med. 2018;11(1):3.
11. Soontorn T, Sitthimongkol Y, Thosingha O, Viwatwongkasem C. Factors influencing the accuracy of triage by registered nurses in trauma patients. Pacific Rim Int J Nurs Res. 2018;22(2):120-30.
12. Winthachai O, Hengrussamee C. [Agreement of Prehospital Severity Assignment: Comparisons among 3 Different Patient Assessment Tools in Urban Emergency Medical Service]. Vajira Med J. 2020;64(3):193-204. Thai.
13. Sri-On J, Vanichkulbodee A, Sinsuwan N, Rojsaengroeng R, Kamsom A, Liu SW. Disaster preparedness among Thai elderly emergency department patients: a survey of patients' perspective. BMC Emerg Med. 2019;19(1):58.
14. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet. 2007;370(9596):1453-7.
15. McHugh ML. Interrater reliability: the kappa statistic.

Biochem Med (Zagreb). 2012;22(3):276-82.
16. Daniel WW. Biostatistics: A foundation for analysis in health sciences. 6th ed: John WileySons, Inc; 1995.
17. Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR. A simulation study of the number of events per variable in logistic regression analysis. J Clin Epidemiol. 1996;49(12):1373-9.
18. Vittinghoff E, McCulloch CE. Relaxing the rule of ten events per variable in logistic and Cox regression. Am J Epidemiol. 2007;165(6):710-8.
19. Suamchaiyaphum K, Chanruangvanich W, Thosingha O, Momsomboon A. [Factors Influencing the Accuracy of Emergency Severity Index-Based Emergency Patient Triage]. JTNMC. 2019;34(4):34-47. Thai.
20. AlSerkal Y, AlBlooshi K, AlBlooshi S, Khan Y, Naqvi SA, Fincham C, et al. Triage Accuracy and Its Association with Patient Factors Using Emergency Severity Index: Findings from United Arab Emirates. Open Access Emerg Med. 2020;12:427-34.
21. Hoyt DB, Schneidman DS. The American College of Surgeons: an enduring commitment to quality and patient care. Am J Surg. 2015;209(3):436-41.
22. Chen S-S, Chen J-C, Ng C-J, Chen P-L, Lee P-H, Chang W-Y. Factors that influence the accuracy of triage nurses' judgement in emergency departments. Emerg Med J. 2010;27(6):451-5.
23. Gorick H. Factors that affect nurses' triage decisions in the emergency department: a literature review. Emerg Nurse. 2022;30(3):14-9.
24. Sun R, Karaca Z, Wong HS. Trends in Hospital Emergency Department Visits by Age and Payer, 2006–2015. Rockville (MD): Agency for Healthcare Research and Quality (US); 2006.
25. Bunyarat S. [Accuracy of Emergency Triage System in Emergency Room at Chiangrai Prachanukroh Hospital: Emergency Severity Index (ESI) compared to Canadian Triage and Acuity Cale (CTAS)]. CRMJ. 2021;13(3):147-59. Thai.
26. Ye L, Zhou G, He X, Shen W, Gan J, Zhang M. Prolonged length of stay in the emergency department in high-acuity patients at a C hinese tertiary hospital. Emerg Med Australas. 2012;24(6):634-40.
27. Sankham P, Utriyaprasit K, Tankumpuan T, Khruekarnchana P. [Predictors of Older Patients' Stay in the Emergency Department]. JTNMC. 2022;37(1):125-45. Thai.
28. Sweeny A, Keijzers G, O'Dwyer J, Arendts G, Crilly J. Predictors of a long length of stay in the emergency department for older people. Intern Med J. 2020;50(5):572-81.
29. Rashid K, Ullah M, Ahmed ST, Sajid MZ, Hayat MA, Nawaz B, et al. Accuracy of Emergency Room Triage Using Emergency Severity Index (ESI): Independent Predictor of Under and Over Triage. Cureus. 2021;13(12):e20229.
30. Benjamin ER, Khor D, Cho J, Biswas S, Inaba K, Demetriades D. The age of undertriage: current trauma triage criteria underestimate the role of age and comorbidities in early mortality. J Emerg Med. 2018;55(2):278-87.

Table 1: Patient demographics and clinical characteristics

Variables	Overall (n = 1000)		Triage result					
			Correct (n = 691)		Over-triage (n = 260)		Under-triage (n = 49)	
Gender	n	%	n	%	n	%	n	%
Male	524	(52.4)	356	(51.5)	146	(56.2)	22	(44.9)
Female	476	(47.6)	335	(48.5)	114	(43.8)	27	(55.1)
Age (years)	47.94 ± 21.81		49.59 ± 21.92		44.15 ± 20.82		44.67 ± 23.00	
18–30 years	295	(29.5)	180	(26.0)	95	(36.5)	20	(40.8)
30–49 years	223	(22.3)	159	(23.0)	55	(21.2)	9	(18.4)
50–65 years	219	(21.9)	149	(21.6)	61	(23.5)	9	(18.4)
≥65 years	263	(26.3)	203	(29.4)	49	(18.8)	11	(22.4)
Comorbidities								
No	573	(57.3)	386	(55.9)	162	(62.3)	25	(51.0)
Yes	427	(42.7)	305	(44.1)	98	(37.7)	24	(49.0)
Type of patients								
Non-trauma	666	(66.6)	489	(70.8)	139	(53.5)	38	(77.6)
Trauma	334	(33.4)	202	(29.2)	121	(46.5)	11	(22.4)
Transportation to ED								
Walk in	915	(91.5)	625	(90.4)	243	(93.5)	47	(95.9)
Ambulance	85	(8.5)	66	(9.6)	17	(6.5)	2	(4.1)
Arrival time								
Morning shift (8.00–15.59)	346	(34.6)	251	(36.3)	82	(31.5)	13	(26.5)
Evening shift (16.00–23.59)	452	(45.2)	297	(43.0)	126	(48.5)	29	(59.2)
Night shift (0.00–7.59)	202	(20.2)	143	(20.7)	52	(20.0)	7	(14.3)
Chief complaints								
Abdominal pain	99	(9.9)	74	(10.7)	22	(8.5)	3	(6.1)
Allergic	17	(1.7)	12	(1.7)	5	(1.9)	0	(0.0)
Altered mental status	34	(3.4)	29	(4.2)	3	(1.2)	2	(4.1)
Animal bites	38	(3.8)	20	(2.9)	18	(6.9)	0	(0.0)
Chest pain	31	(3.1)	27	(3.9)	1	(0.4)	3	(6.1)
Dizziness	38	(3.8)	30	(4.3)	7	(2.7)	1	(2.0)
Dysrhythmia	6	(0.6)	5	(0.7)	1	(0.4)	0	(0.0)
Edema	3	(0.3)	3	(0.4)	0	(0.0)	0	(0.0)
Ear, nose, and throat	24	(2.4)	11	(1.6)	12	(4.6)	1	(2.0)
Fever	72	(7.2)	48	(6.9)	19	(7.3)	5	(10.2)
Genitourinary	20	(2.0)	19	(2.7)	0	(0.0)	1	(2.0)
Gastrointestinal bleeding	19	(1.9)	12	(1.7)	6	(2.3)	1	(2.0)
Headache	10	(1.0)	7	(1.0)	2	(0.8)	1	(2.0)
Hypertension	5	(0.5)	4	(0.6)	1	(0.4)	0	(0.0)
Labor pain	29	(2.9)	25	(3.6)	1	(0.4)	3	(6.1)
Lower respiratory tract infection	7	(0.7)	6	(0.9)	0	(0.0)	1	(2.0)
Musculoskeletal (atraumatic)	31	(3.1)	24	(3.5)	3	(1.2)	4	(8.2)
Musculoskeletal (isolated trauma)	29	(2.9)	19	(2.7)	7	(2.7)	3	(6.1)
Neurologic	29	(2.9)	19	(2.7)	9	(3.5)	1	(2.0)
Nausea, vomiting, and diarrhea	42	(4.2)	25	(3.6)	14	(5.4)	3	(6.1)
Seizure	13	(1.3)	10	(1.4)	2	(0.8)	1	(2.0)
Shortness of breath	68	(6.8)	50	(7.2)	14	(5.4)	4	(8.2)
Skin, nails, and hair	4	(0.4)	0	(0.0)	4	(1.5)	0	(0.0)
Substance abuse	4	(0.4)	2	(0.3)	2	(0.8)	0	(0.0)
Syncope	21	(2.1)	15	(2.2)	6	(2.3)	0	(0.0)
Trauma	254	(25.4)	155	(22.4)	91	(35.0)	8	(16.3)
Upper respiratory tract infection	29	(2.9)	20	(2.9)	7	(2.7)	2	(4.1)
Weakness	7	(0.7)	5	(0.7)	1	(0.4)	1	(2.0)
Wound	1	(0.1)	1	(0.1)	0	(0.0)	0	(0.0)
Other	16	(1.6)	14	(2.0)	2	(0.8)	0	(0.0)
Hospital admission								
No	713	(71.3)	452	(65.4)	227	(87.3)	34	(69.4)
Yes	287	(28.7)	239	(34.6)	33	(12.7)	15	(30.6)
Critical outcomes								
Discharge	668	(66.8)	415	(60.1)	220	(84.6)	33	(67.3)

Table 1: Patient demographics and clinical characteristics

Variables	Overall (n = 1000)		Triage result					
			Correct (n = 691)		Over-triage (n = 260)		Under-triage (n = 49)	
Hospital admission	287	(28.7)	239	(34.6)	33	(12.7)	15	(30.6)
Hospital transfer	39	(3.9)	31	(4.5)	7	(2.7)	1	(2.0)
Death	4	(0.4)	4	(0.6)	0	(0.0)	0	(0.0)
Against advice	2	(0.2)	2	(0.3)	0	(0.0)	0	(0.0)
Systolic blood pressure (mmHg)								
Mean ± SD	137.98±26.74		138.38 ± 27.37		137.86 ± 25.32		132.92 ± 25.14	
<90 mmHg	10	(1.0)	10	(1.4)	0	(0.0)	0	(0.0)
90-160 mmHg	817	(81.7)	559	(80.9)	214	(82.3)	44	(89.8)
>160 mmHg	173	(17.3)	122	(17.7)	46	(17.7)	5	(10.2)
Diastolic blood pressure (mmHg)								
Mean ± SD	82.23 ± 16.73		82.12 ± 17.32		83.15 ± 15.26		78.94 ± 15.66	
<60	61	(6.1)	44	(6.4)	13	(5.0)	4	(8.2)
60-110	888	(88.8)	610	(88.3)	234	(90.0)	44	(89.8)
>110	51	(5.1)	37	(5.4)	13	(5.0)	1	(2.0)
Heart rate (beats/min)	88.15 ± 19.4		88.23 ± 19.85		87.97 ± 18.67		87.98 ± 16.97	
<60	34	(3.4)	25	(3.6)	9	(3.5)	0	(0.0)
60-100	765	(76.5)	523	(75.7)	201	(77.3)	41	(83.7)
>100	201	(20.1)	143	(20.7)	50	(19.2)	8	(16.3)
Respiratory rate (cycles/min)	20.24 ± 4.08		20.51 ± 4.44		19.59 ± 3.02		19.98 ± 3.28	
<12	2	(0.2)	2	(0.3)	0	(0.0)	0	(0.0)
12-20	768	(76.8)	512	(74.1)	215	(82.7)	41	(83.7)
>20	214	(21.4)	163	(23.6)	44	(16.9)	7	(14.3)
Unmeasurable	16	(1.6)	14	(2.0)	1	(0.4)	1	(2.0)
Oxygen saturation (%)								
Median (IQR)	98(97 - 100)		98(96 - 100)		99(97.5 - 100)		98(96 - 99)	
<90	31	(3.1)	30	(4.3)	1	(0.4)	0	(0.0)
>90	687	(68.7)	478	(69.2)	179	(68.8)	30	(61.2)
Unmeasurable	282	(28.2)	183	(26.5)	80	(30.8)	19	(38.8)
Body temperature (°C)	37.16 ± 1.08		37.15 ± 1.07		37.23 ± 1.11		36.94 ± 1.02	
<37.5	462	(46.2)	331	(47.9)	105	(40.4)	26	(53.1)
≥37.5	176	(17.6)	130	(18.8)	39	(15.0)	7	(14.3)
Unmeasurable	362	(36.2)	230	(33.3)	116	(44.6)	16	(32.7)
Pain score								
Mean ± SD	6.90 ± 2.45		7.12 ± 2.48		5.88 ± 2.26		7.67 ± 1.86	
Mild (0–3)	13	(1.3)	10	(1.4)	3	(1.2)	0	(0.0)
Moderate (4–7)	54	(5.4)	35	(5.1)	17	(6.5)	2	(4.1)
Severe (8–10)	59	(5.9)	50	(7.2)	5	(1.9)	4	(8.2)
None (missing)	874	(87.4)	596	(86.3)	235	(90.4)	43	(87.8)
Glasgow coma scale								
Median (IQR)	15(15 - 15)		15(15 - 15)		15(15 - 15)		15(15 - 15)	
<15	70	(7.0)	59	(8.5)	7	(2.7)	4	(8.2)
15	930	(93.0)	632	(91.5)	253	(97.3)	45	(91.8)
Capillary blood glucose (%)								
Mean ± SD	168.67±89.13		167.87 ± 89.39		170.3 ± 90.27		175.9 ± 89.87	
<100	29	(2.9)	21	(3.0)	7	(2.7)	1	(2.0)
≥100	173	(17.3)	138	(20.0)	26	(10.0)	9	(18.4)
None (missing)	798	(79.8)	532	(77.0)	227	(87.3)	39	(79.6)

Data are presented as number (%), mean ± standard deviation or median (interquartile range). SD: standard deviation; IQR: interquartile range; ED: emergency department.

Table 2: Univariable analysis for factors associated with under-triage and over-triage

Variables	Over-triage			Under-triage		
	OR	95%CI	p-value	OR	95%CI	p-value
Gender						
Male	1.00	Reference		1.00	Reference	
Female	0.83	(0.62 - 1.11)	0.202	1.30	(0.73 - 2.33)	0.371
Age (years)						
18–30 years	2.19	(1.47 - 3.26)	<0.001*	2.05	(0.96 - 4.4)	0.065
30–49 years	1.43	(0.93 - 2.22)	0.107	1.04	(0.42 - 2.58)	0.925
50–65 years	1.70	(1.10 - 2.61)	0.016*	1.11	(0.45 - 2.76)	0.814
≥65 years	1.00	Reference		1.00	Reference	
Comorbidities						
No	1.00	Reference		1.00	Reference	
Yes	0.77	(0.57 - 1.03)	0.073	1.21	(0.68 - 2.17)	0.510
Type of patients						
Non-trauma	1.00	Reference		1.00	Reference	
Trauma	2.11	(1.57 - 2.83)	<0.001*	0.70	(0.35 - 1.40)	0.313
Transportation to ED						
Walk in	1.00	Reference		1.00	Reference	
Ambulance	0.66	(0.38 - 1.15)	0.145	0.40	(0.10 - 1.70)	0.215
Arrival time						
Morning shift (8.00–15.59)	1.00	Reference		1.00	Reference	
Evening shift (16.00–23.59)	1.30	(0.94 - 1.80)	0.115	1.89	(0.96 - 3.7)	0.066
Night shift (0.00–7.59)	1.11	(0.74 - 1.67)	0.603	0.95	(0.37 - 2.42)	0.906
Hospital admission						
No	1.00	Reference		1.00	Reference	
Yes	0.27	(0.18 - 0.41)	<0.001*	0.83	(0.45 - 1.56)	0.572
Systolic blood pressure (mmHg)						
Normal	1.00	Reference		1.00	Reference	
Abnormal	0.91	(0.63 - 1.32)	0.619	0.48	(0.19 - 1.24)	0.129
Diastolic blood pressure (mmHg)						
Normal	1.00	Reference		1.00	Reference	
Abnormal	0.84	(0.52 - 1.33)	0.454	0.86	(0.33 - 2.22)	0.749
Heart rate (beats/min)						
Normal	1.00	Reference		1.00	Reference	
Abnormal	0.91	(0.65 - 1.28)	0.601	0.61	(0.28 - 1.32)	0.209
Respiratory rate (cycles/min)						
Normal	1.00	Reference		1.00	Reference	
Abnormal	0.64	(0.44 - 0.92)	0.016*	0.53	(0.23 - 1.20)	0.129
Oxygen saturation (%)						
<90	0.09	(0.01 - 0.66)	0.018*	-	-	NA
>90	1.00	Reference		1.00	Reference	
Body temperature (°C)						
<37.5	1.00	Reference		1.00	Reference	
≥37.5	0.95	(0.62 - 1.44)	0.794	0.69	(0.29 - 1.62)	0.389
Pain score						
Mild/Moderate (0–7)	1.00	Reference		1.00	Reference	
Severe (8–10)	0.23	(0.08 - 0.65)	0.006*	1.80	(0.31 - 10.30)	0.509
Glasgow coma scale						
<15	0.30	(0.13 - 0.66)	0.003*	0.95	(0.33 - 2.74)	0.928
15	1.00	Reference		1.00	Reference	
Capillary blood glucose (%)						
<100	1.00	Reference		1.00	Reference	
≥100	0.57	(0.22 - 1.47)	0.240	1.37	(0.16 - 11.37)	0.771

OR: Odds Ratio; CI: confident interval; ED: emergency department; NA: data not applicable.
*: significant difference; Crude Odds Ratio estimated by Multinomial logistic regression.

Table 3: Multivariable analysis for factors associated with under-triage and over-triage

Variables	Over-triage			Under-triage		
	OR_{adj}	95%CI	p-value	OR_{adj}	95%CI	p-value
Age (years)						
18–30	1.73	(1.07 - 2.81)	0.026*	3.05	(1.16 - 8.00)	0.023*
30–49	1.24	(0.76 - 2.01)	0.391	1.40	(0.52 - 3.81)	0.506
50–65	1.49	(0.93 - 2.38)	0.094	1.23	(0.47 - 3.22)	0.675
≥65	1.00	Reference		1.00	Reference	
Type of patients						
Non-trauma	1.00	Reference		1.00	Reference	
Trauma	1.80	(1.29 - 2.52)	0.001*	0.73	(0.34 - 1.57)	0.424
Arrival time						
Morning shift (8.00–15.59)	1.00	Reference		1.00	Reference	
Evening shift (16.00–23.59)	1.42	(1.01 - 2.00)	0.046*	1.68	(0.84 - 3.36)	0.142
Night shift (0.00–7.59)	1.21	(0.79 - 1.86)	0.383	0.83	(0.32 - 2.17)	0.705
Hospital admission						
No	1.00	Reference		1.00	Reference	
Yes	0.35	(0.22 - 0.54)	<0.001*	0.95	(0.46 - 1.95)	0.890
Pain score						
Mild/Moderate (0–7)	1.00	Reference		1.00	Reference	
Severe (8–10)	0.28	(0.10 - 0.84)	0.023*	1.81	(0.30 - 10.8)	0.514

ORadj: Adjusted Odds Ratio; CI: confident interval; NA: data not applicable.
Variables were included in multivariable model due to having p-value < 0.200 in uni-variable analysis.
*: significant difference; Adjusted Odds Ratio estimated by Multinomial logistic regression.