Original Article

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Emergency Department Length of Stay and in-Hospital Mortality of Non-Traumatic Patients in a University Hospital

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Abstract:

Objective: To assess the emergency department length of stay (EDLOS) and mortality in each Emergency Severity Index (ESI) triage level. In addition to identifying the cut-off point of EDLOS to predict 72-hour in-hospital mortality among adult non-traumatic patients in the ED of a university hospital.

Material and Methods: A cross-sectional study was conducted by retrieving patient data from the hospital information system; from January 1, 2014, to December 31, 2018. Patient characteristics, EDLOS, and in-hospital mortality rates were analyzed using the R program. The cut-off values of EDLOS, via the area under the curve for the best prediction of 72-hour in-hospital mortality in patients at different ESI levels, were analyzed by multivariate analysis. Statistical significance was defined as a p-value of ≤0.05.

Results: Data from 71,247 patients with 123,356 visits were enrolled. EDLOS significantly decreased across ESI levels and the in-hospital mortality rates were highest in ESI 1, followed by ESI 2 and ESI 3. The predictive ability of EDLOS was the highest for ESI 4, followed by ESI 3. The cut-off point of EDLOS at 3.58 hours showed the best sensitivity, which was a significant risk factor for mortality after adjusting for other significant variables. An EDLOS longer than 4 hours was a significant factor for poor survival in patients with ESI 2 and ESI 3.

Conclusion: A practical cut-off point of 4 hours EDLOS can be used to predict 72-hour in-hospital mortality. Healthcare providers in the ED should consider EDLOS as a safety indicator for quality assurance.

Keywords: emergency room, emergency severity index, length of stay, mortality, prediction, triage

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Introduction

Accessible emergency departments (EDs), with prompt 24-hour service delivery and a sufficient healthcare workforce, are essential components of the healthcare system for saving lives and improving the health of people[1]. Due to the high volume of ED visits in high- to low-income countries triage tools; such as the emergency severity index (ESI), Canadian Triage and Acuity Scale, or national early warning score (NEWS), are used to screen and prioritize urgent patients for medical care[2-3]. However, with several limitations; such as in-hospital bed availability or the variety of investigations and management, some patients may need to stay longer in the ED[4]. Prolonged emergency department length of stay (EDLOS) is associated with ED crowding, which results in unfavorable patient outcomes; especially increased risks of mortality[5-9].

Recently, reducing patient EDLOS and ED crowding have been the major challenges in the ED and public health systems globally[5-9]. Less EDLOS and ED crowding have the potential to greatly impact the quality of care and improve favorable outcomes[10]. The National Emergency Access Target of Australia stipulates that patients should be admitted, discharged, or transferred from Australian EDs within 4 hours of presentation to the ED[11]. The New South Wales Ministry of Health also published the 4-hour emergency access target: 2 hours for ED assessment, 1 hour for specialist interventions, and 1 hour for transfer care, and this has also been used in Australia, New Zealand and the United Kingdom[12-14]. A retrospective study conducted in Australia showed lower in-hospital mortality in patients with 4-hour EDLOS compared to those with EDLOS longer than 4 hours[15].

Boarding time, the duration from admission decision to bed arrival, has a major influence on ED crowding and it also increases EDLOS[16]. The effect of boarding time tends to increase the in-hospital mortality and may cause harm to patients in some studies ; however, other studies have shown no significant results[16-18].

Prolonged EDLOS has been shown to increase the risk of inpatient morbidity or mortality in the intensive care unit for patients with sepsis, intracerebral hemorrhage, and ischemic stroke, or those requiring critical care[19-22]. Yet, the cut-off values for EDLOS have not been determined or suggested, most likely because of the different health systems and contexts in each country. To date, there are limited studies that have identified the average EDLOS in adult non-traumatic patients, and no study has been conducted based on the triage category and mortality. The targeted EDLOS could be the initial data for establishing prediction rules in the ED. This may also improve managing crowding and maintaining the quality of care for prompt service delivery and hospital management.

Songklanagarind Hospital is a tertiary hospital wherein the ED provides services to approximately 50,000 patients annually. Its 5-level ESI triage system, a valid and reliable triage tool, was implemented to prioritize patients into immediate, emergent, urgent, acute non-urgent, and non-urgent categories. Each patient in a specific triage level is guaranteed to receive appropriate care within specific times: ESI 1 is immediate, without delay, ESI 2 is emergent, no later than 10 minutes, ESI 3 is urgent, within 30 minutes, ESI 4 is acute non-urgent within 1 hour, and ESI 5 is non-urgent; without guarantee[2]. Identifying the EDLOS of each patient in each triage level and correlating between EDLOS and patient outcome (in-hospital mortality) will provide valuable information for EDs, and help with hospital resource allocation and management. Therefore, the objectives of this study aimed to assess the EDLOS and mortality in each triage ESI level and identify the cut-off point of EDLOS to predict 72-hour in-hospital mortality. This excluded patients who died in ED among adult non-traumatic patients at the ED of a university hospital.

Material and Methods

A cross-sectional study was conducted by retrieving patient data from the hospital information system of

Songklanagarind Hospital. All data was retrieved from the hospital information systems (HIS) electronic database; no paper records were assessed. The data were then de-identified and kept confidential. Therefore, the need for informed consent was waived by the Institutional Review Board of the Faculty of Medicine, Prince of Songkla University (REC.60-219-20-4).

Non-traumatic patients, aged at least 15 years, who visited the ED between January 1, 2014 and December 31, 2018, were included. Patients who were referred to this hospital, died before arrival, or had incomplete information were excluded. The main outcome was 72-hour in-hospital mortality due to any causes. The main exposure of interest was EDLOS, defined as the duration from registration at the emergency department in the triage area to disposition or death, measured in hours. Other independent variables were age, gender, time of visit, emergency medical services, primary diagnosis, and ESI levels. The ESI levels were classified as ESI 1–ESI 5.

The data were merged and analyzed using R program version 4.0.5 (The R Foundation for Statistical Computing, 2020; Vienna, Austria). Patient information was descriptively analyzed using medians, with interquartile ranges (IQRs) for continuous data and percentages for categorical data. The EDLOS and in-hospital mortality across each ESI level were analyzed using the Kruskal–Wallis test or chi-square test; as appropriate. The cut-off values of EDLOS for the best prediction of 72-hour in-hospital mortality at different ESI levels were analyzed using the area under the curve (AUC) when the receiver operating characteristic (ROC) curve was plotted. An AUC of ≥ 0.7 was considered acceptable. The most appropriate EDLOS cut-off point was selected based on its high sensitivity and acceptable specificity as a warning tool for the early screening of patients at high risk for in-hospital mortality. This cut-off point was tested to predict 72-hour in-hospital mortality after adjusting for other independent variables using the Cox regression model. The practical cut-off point was also analyzed for its prediction using the Kaplan–Meier curve. Statistical significance was set at p-value<0.05.

Results

There were 259,409 ED visits from January 2014 to December 2018, and 71,247 patients (123,356 visits) were enrolled in the study. The median age (IQR) of the patients decreased from ESI1 through to ESI 5. The patient's information is presented in Table 1. Male gender was prominent in patients with ESI 1 and ESI2; mainly presenting with circulatory and respiratory conditions. Table 2 shows length of stay and mortality of participants in each triage category; as classified by ESI levels. Median EDLOS in ESI 1, 2, 3, 4, and 5 groups were 5.2, 4.2, 3.1, 2, and 1.3 hours, respectively. The admission length of stay, duration from in-patient register to discharge, are demonstrated in Table1. The 72-hour in-hospital mortality rate in ESI 1 was 19.6% and that in ESI 2 and ESI 3 was 1.4%, and 0.1%, respectively. The overall median (IQR) EDLOS was 2.8 (1.6, 4.8) hours, and the overall 72-hour in-hospital mortality was 0.5%.

The predictive ability of EDLOS was highest in patients in ESI 4 (AUC 0.93), followed by ESI3 (AUC 0.79) (Figure 1). The patients with ESI5 were excluded due to no mortality, while there were only three mortalities in patients with ESI4; therefore, the ROC curve may not represent the true value. The cut-off value of EDLOS at 3.58 hours showed the best sensitivity (89.1%) as well as acceptable specificity (58.6%) to be used as a screening tool for early warning of 72-hour in-hospital mortality in patients with ESI 3.

Univariate and multivariate analyses for predicting 72-hour mortality in non-traumatic adult patients at the ED are presented in Table 3. The hazard ratio (HR) of mortality in patients aged 60 years or older was significantly higher when compared to those who were younger in univariate,

Table 1 Enrolled patient information in the study

Patient information	ESI 1 n=1,427	ESI 2 n=22,206	ESI 3 n=60,178	ESI 4 n=33,565	ESI 5 n=5,793	Total N=123,356
Age (years)†	67 (54,80)	65 (52,77)	57 (39,72)	45 (26,62)	30 (22,50)	55 (35,71)
Male gender	816 (57.2)	12,027 (54.2)	26,789 (44.5)	12,484 (37.2)	2,152 (37.2)	54,268 (44.1)
Time of visit						
Afternoon shift	537 (37.6)	8,268 (37.2)	23,677 (39.3)	13,087 (39)	2,519 (43.5)	48,088 (39.1)
Morning shift	634 (44.5)	10,208 (46)	26,768 (44.5)	14,047 (41.9)	2,145 (37)	53,802 (43.6)
Night shift	256 (17.9)	3,723 (16.8)	9,722 (16.2)	6,420 (19.1)	1,127 (19.5)	21,248 (17.3)
Emergency Medical Service	229 (16.0)	747 (3.4)	442 (0.7)	166 (0.5)	7 (0.1)	1,591 (1.3)
Primary diagnosis categories						
Infectious disease	33 (2.3)	425 (1.9)	2,939 (4.9)	2,636 (7.9)	513 (8.8)	6,546 (5.3)
Circulatory	494 (34.6)	4,485 (20.2)	3,799 (6.3)	630 (1.9)	126 (2.2)	9,534 (7.7)
Digestive	41 (2.9)	1,161 (5.2)	7,778 (12.9)	5,115 (15.2)	671 (11.5)	14,766 (12.0)
Genitourinary	45 (3.2)	967 (4.4)	6,205 (10.4)	2,058 (6.2)	137 (2.4)	9,412 (7.7)
Musculoskeletal	7 (0.5)	476 (2.1)	5,383 (8.9)	3,265 (9.7)	428 (7.4)	9,559 (7.8)
Respiratory	249 (17.4)	4,964 (22.4)	2,787 (4.6)	1,788 (5.3)	1,093 (18.9)	10,881 (8.8)
Endocrine and metabolic	114 (8.0)	797 (3.6)	978 (1.6)	230 (0.7)	40 (0.7)	2,159 (1.8)
Neoplasms	80 (5.6)	1,030 (4.6)	2,756 (4.6)	688 (2.0)	44 (0.8)	4,598 (3.7)
Other	364 (25.5)	7,901 (35.6)	27,552 (45.8)	17,154 (51.1)	2,741 (47.3)	55,712 (45.2)

Data are presented as n (%) or †median (IQR1, IQR3)
ESI=Emergency Severity Index, IQR=interquartile range

Table 2 Length of stay and mortality of participants in each triage category classified by ESI levels

Factors	ESI 1 n=1,464	ESI 2 n=22,347	ESI 3 n=60,258	ESI 4 n=33,570	ESI 5 n=5,793	Total N=123,621	p-value
ED Disposition							<0.001
Admit	1,049 (74.7)	10,126 (45.9)	12,318 (20.5)	1,623 (4.8)	210 (3.6)	25,326 (20.6)	
Dead	126 (9.0)	49 (0.2)	7 (0.0)	0 (0.0)	0 (0.0)	182 (0.1)	
Discharge	229 (16.3)	11,884 (53.9)	47,687 (79.5)	31,884 (95.2)	5,578 (96.4)	97,262 (79.2)	
EDLOS† (hours)	5.2 (3,7.9)	4.2 (2.5,6.7)	3.1 (1.9,5)	2 (1.2,3.4)	1.3 (0.7,2.4)	2.8 (1.6,4.8)	<0.001
ICU admission	178 (18.8)	664 (9.1)	143 (1.6)	7 (0.7)	1 (1.5)	993 (5.4)	<0.001
Admission LOS† (days)	8 (3,16)	7 (4,13)	5 (3,10)	4 (2,8)	3 (2,6)	6 (3,12)	<0.001
72-hour mortality	279 (19.6)	315 (1.4)	55 (0.1)	3 (0.0)	0 (0.0)	652 (0.5)	<0.001
28-day mortality	417 (29.2)	866 (3.9)	274 (0.5)	12 (0.0)	0 (0.0)	1,569 (1.3)	<0.001

Data are presented as n (%) or †median (IQR1, IQR3)
ED=emergency department, EDLOS=emergency department length of stay, ESI=Emergency Severity Index, ICU=intensive care unit, IQR=interquartile range

Table 3 Univariate and multivariate analysis for predicting 72-hour mortality in non-traumatic adult patients at the ED

Factors	Univariate analysis		Multivariate analysis		
	HR (95% CI)	p-value (Wald's test)	adj. HR (95% CI)	p-value (Wald's Test)	p-value (LR Test)
EDLOS (ref: < 3.58 hours)					<0.001
≥ 3.58	11.54 (4.94,26.93)	<0.001	9.31 (3.96,21.85)	<0.001	
Age group (ref:15-30 years old)					0.005
30–45	2.15 (0.42,11.07)	0.361	1.71 (0.33,8.87)	0.523	
45–60	2.22 (0.46,10.66)	0.321	1.37 (0.28,6.68)	0.700	
≥60	7.01 (1.69,28.97)	0.007	3.93 (0.93,16.55)	0.062	
Sex (ref: female)					0.224
Male	1.61 (0.95,2.74)	0.08	1.39 (0.81,2.38)	0.226	
Time of visit (ref: afternoon)					0.265
Morning	0.81 (0.46,1.43)	0.476	0.63 (0.35,1.1)	0.106	
Night	0.68 (0.29,1.58)	0.371	0.71 (0.31,1.65)	0.429	
Primary diagnosis (ref: digestive system)					<0.001
Infectious disease	1.32 (0.24,7.22)	0.746	1.61 (0.29,8.83)	0.582	
Circulatory system	6.15 (1.98,19.07)	0.002	3.97 (1.28,12.39)	0.017	
Genitourinary system	1.25 (0.31,5.01)	0.749	1.30 (0.32,5.19)	0.714	
Musculoskeletal system	0.36 (0.04,3.23)	0.362	0.47 (0.05,4.25)	0.505	
Respiratory system	2.09 (0.47,9.35)	0.333	2.10 (0.47,9.4)	0.332	
Endocrine and metabolic diseases	7.97 (1.99,31.85)	0.003	4.87 (1.21,19.55)	0.026	
Neoplasms	7.06 (2.22,22.53)	<0.001	6.00 (1.88,19.17)	0.003	
Other	1.06 (0.35,3.19)	0.919	1.14 (0.38,3.44)	0.817	

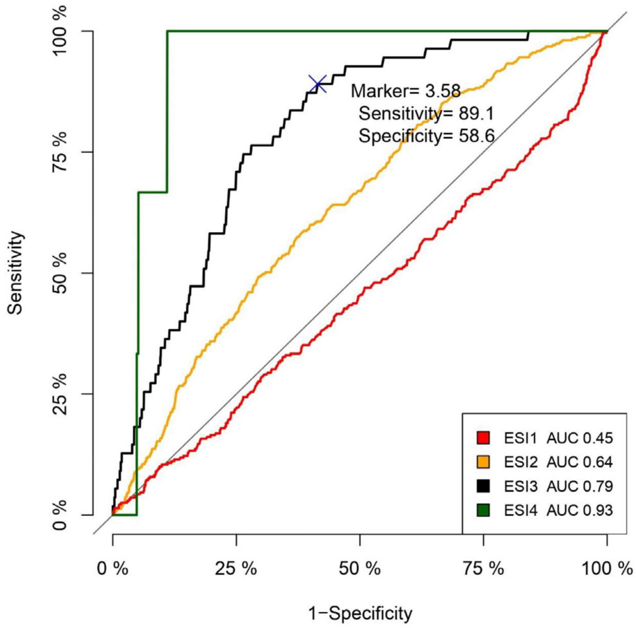
LR=likelihood ratio, CI=confidence interval, ED=emergency department, EDLOS=emergency department length of stay, HR=hazard ratio, ref=reference

but not in multivariate analysis. Gender and time of visit were not significant in either analysis. An EDLOS of at least 3.58 hours was a significant risk factor for mortality (adjusted HR 9.31, 95% confidence interval (CI) 3.96-21.85). Patients with a primary diagnosis related to the circulatory system, endocrine and metabolic, and neoplasm had a significantly increased mortality risk compared to patients with a digestive system (adjusted HR 3.97, 95% CI. 1.28, 12.39), endocrine and metabolic (adjusted HR 4.87, 95% CI. 1.21, 19.55), or neoplasm (adj. HR 6, 95% CI. 1.88, 19.17) disease. Figure 2 shows the Kaplan-Meier survival curve of in-hospital mortality via 4-hour time groups of EDLOS. There were significant differences of survival across groups among patients with ESI 2 (Figure 2A, p-value<0.001) and among patients with ESI 3 (Figure 2B, p-value<0.001).

Discussion

Adult non-traumatic patients with serious ESIs were more likely to have a long EDLOS and high mortality. Longer EDLOS in patients with ESI 2 and ESI 3 had a significantly higher in-hospital mortality. There was low in-hospital mortality in patients with ESI 4, and no mortality in patients with ESI 5 was observed. The cut-off point of 4-hour EDLOS was valid and useful to predict in-hospital mortality; particularly in serious ESIs.

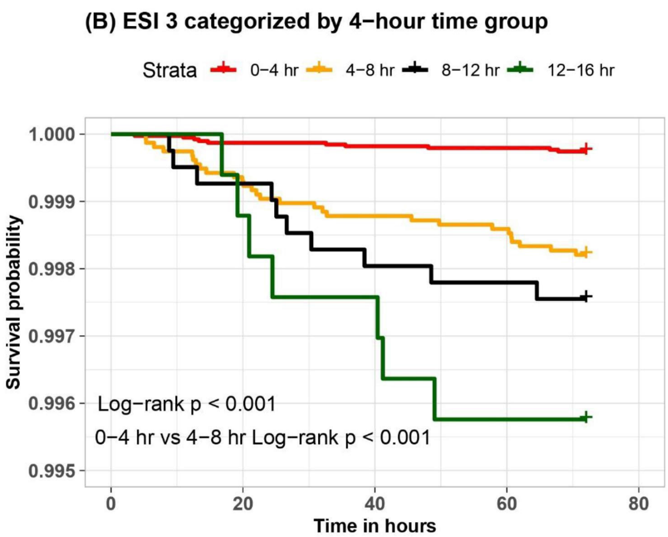
The correlation between the longer EDLOS and in-hospital mortality in this study was consistent with the findings of previous studies. These studies focused on the mortality of patients with overall ED sepsis and ischemic stroke, and patients requiring critical care and intensive care unit admission with long EDLOS[5-9, 19-23]. The severities,



AUC=area under the curve, EDLOS=emergency department length of stay, ESI=Emergency Severity Index, ROC=receiver operating characteristic

Figure 1 ROC curve of EDLOS and 72-hour in-hospital mortality in ESI 1–4 patients

The blue "X" marker is the cut-off point of EDLOS, at 3.58 hours, and the 72-hours in-hospital mortality of the ESI 3 patients



ESI= emergency severity index

Figure 2 Kaplan–Meier Curve on 72-hour in-hospital mortality among patients with ESI 2 categorized by 4-hour time groups (A) and among patients with ESI 3 categorized by 4-hour time groups (B) based on ESI, correlated well with mortality, which was similar to previous studies[24-25]. However, this study found that the median EDLOS was lowest in ESI 5 and highest in ESI 1, which differed from other studies; including a study from Thailand that mostly had longer EDLOS in those with lower ESI. Differences in sample size and analytic methods might explain this paradox[26-27]. Relatively, long EDLOS in serious ESI in this study's setting might be a result of the consultation system and investigations; usually, a definite diagnosis was made before discharge from the emergency department.

No cut-off values of EDLOS that could identify the probability of mortality have been determined or suggested in previous studies. The EDLOS at 3.58 hours was shown to be the best cut-off point to predict 72-hour in-hospital mortality in patients with ESI 3. The EDLOS ≥3.58 hours remained significant after adjusting for age, time of visit, and primary diagnosis in the multivariate analysis for determining in-hospital mortality. However, the cut-off point at 3.58 hours might not be practical; thus, the EDLOS was categorized into four groups using 4-hour intervals (0–4 hours, >4–8 hours, >8–12 hours, and >12–16 hours). This study's findings were also supported by the fact that patients with ESI 2 and ESI 3 with EDLOS longer than 4 hours had higher mortality than those with 0–4-hour EDLOS (Figure 2). This finding was consistent with a study from Australia in 2016, which recommended 4 hours of EDLOS for all patients visiting the ED[11-15].

The high mortality in patients with ESI 1 in this study supported the application of ESI as a triage tool for adult non-traumatic patients in the ED, which divided the patients into ESI 1 to ESI 5 as immediate, emergent, urgent, acute non-urgent and non-urgent categories, respectively. In addition to EDLOS and ESI triage levels, older patients (age ≥60 years) or those diagnosed with circulatory system, endocrine and metabolic, and neoplasm diseases were more likely to have in-hospital mortality. This result was consistent with previous studies that revealed that older patients visiting the ED had higher mortality compared to younger patients[28-30]. The primary diagnoses of circulatory, endocrine and metabolic, and neoplasm diseases also significantly increased the risk of in-hospital mortality compared to patients with digestive system diseases. These primary diagnoses have high mortality rates in various hospital settings in low-, middle-, and high-income countries[31].

Longer EDLOS in ESI 1 than in ESI 5 in this study was opposite to the findings of a previous study in Thailand. However, their sample sizes and the analytic methods were different; additionally, mortality by ESI was not measured[27]. Long EDLOS in serious ESI in our setting may depend on the consultation system and investigations for a definite diagnosis before admission. The high mortality in patients with ESI 1 in this study supported the application of ESI as a triage tool for adult non-traumatic patients in the ED, which divided the patients into ESI 1 to ESI 5 as: immediate, emergent, urgent, acute non-urgent and non-urgent categories, respectively[2, 24-27, 32].

Four-hour EDLOS was the appropriate and practical cut-off point of EDLOS to predict 72-hour mortality in patients with ESI 2 and ESI 3. This cut-off value might be used as a trigger tool in risk management in the ED, as a quality assurance process to prevent or mitigate unfavorable outcomes. Reducing EDLOS is important to decrease ED crowding and the risk of in-hospital mortality[6-9, 24-27]. This study was originally integrated with the primary diagnosis of patients in the ED using ICD10, with ESI triage to identify correlations with in-hospital mortality. EDLOS within this setting, involving non-traumatic patients, showed opposite findings of mortality when compared with a study in Qatar; which included traumatic patients[33]. This may be due to different baseline characteristics and severity.

This study has several limitations. First, the study was conducted using secondary data from the hospital information system for analysis; hence, there were no waiting times, nor boarding times documented. Second, this study mainly focused on in-hospital mortality without determining in-hospital morbidity, which is another consequence of EDLOS and ED crowding. Finally, all data were extracted from a single university hospital, which may not be similar to other healthcare facilities. Further studies should be conducted to apply the cut-off point of EDLOS as a warning tool in the ED. Furthermore, further investigations to identify the correlation between ESI 1 and ESI 4 and 72-hour in-hospital mortality and morbidity is needed. More studies should be conducted in other triage modalities to predict in-hospital mortality according to EDLOS; such as the National Early Warning Score, which has high sensitivity and acceptable specificity for patients with sepsis[34].

Conclusion

The 4-hour EDLOS cut-off point can be used to predict 72-hour in-hospital mortality. Healthcare providers in the ED should consider EDLOS as a safety indicator for quality assurance.

Author contributions

Wainik Sookmee performed the literature search, study design, data collection, data analysis, data interpretation; and manuscript writing. Tippawan Liabsuetrakul designed the study, analyzed the data, interpreted the data and wrote the manuscript. Siriwimon Tantarattanapong designed this study. Prasit Wuthisuthimethawee performed a literature search, study design and critical revision.

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Conflict of interest

The authors declare no potential conflicts of interest, with respect to the research, authorship and/or publication of this article.

References

1. Guiding principles for national health workforce strategies [homepage on the Internet]. Geneva: World Health Organization [cited 2022 Jan 17]. Available from: https://www.who.int/healthsystems/round9_6.pdf.
2. Kanjanarod K, Techato P, Wuthisuthimethawee P. Validity and reliability of ESI v.4 at Emergency Department Songklanagarind Hospital. 12th Reg Med J 2010;21:1–9.
3. Alam N, Vegting IL, Houben E, van Berkel B, Vaughan L, Kramer MH, et al. Exploring the performance of the National Early Warning Score (NEWS) in a European emergency department. Resuscitation 2015;90:111–5.
4. Patient emergency department total length of stay (LOS) [homepage on the Internet]. Alberta: Health Quality Council of Alberta [cited 2022 Jan 17]. Available from: https://focus.hqca.ca/emergencydepartments/total-length-of-patients-emergency-department-stay-los.
5. Policy statement: Crowding [homepage on the Internet]. Texas: American College of Emergency Physicians; 2019 [cited 2022 Dec 11]. Available from: https://www.acep.org/siteassets/new-pdfs/policy-statements/crowding.pdf
6. Sun BC, Hsia RY, Weiss RE, Zingmond D, Liang LJ, Han W, et al. Effect of emergency department crowding on outcomes of admitted patients. Ann Emerg Med 2013;61:605–11.e6.
7. Guttmann A, Schull MJ, Vermeulen MJ, Stukel TA. Association between waiting times and short term mortality and hospital admission after departure from emergency department: population based cohort study from Ontario, Canada. BMJ 2011;342:d2983.
8. Richardson DB. Increase in patient mortality at 10 days associated with emergency department overcrowding. Med J Aust 2006;184:213–6.

9. Sprivulis PC, Da Silva JA, Jacobs IG, Frazer AR, Jelinek GA. The association between hospital overcrowding and mortality among patients admitted via Western Australian emergency departments. Med J Aust 2006;184:208–12.
10. Sullivan CM, Staib A, Flores J, Aggarwal L, Scanlon A, Martin JH, et al. Aiming to be NEAT: safely improving and sustaining access to emergency care in a tertiary referral hospital. Aust Health Rev 2014;38:564–74.
11. Sullivan C, Staib A, Khanna S, Good NM, Boyle J, Cattell R, et al. The National Emergency Access Target (Neat) And The 4-Hour Rule: Time To Review The Target. Med J Aust 2016;204:354.
12. Emergency department models of care [homepage on the Internet]. New South Wales: Nsw Ministry of Health; 2012. [cited 2022 Jan 17]. Available from: http://www.health.nsw.gov.au.
13. Clinical exceptions to the 4 hour emergency care target [homepage on the Internet]. Sheffield: Department of Health; 2003 [cited 2022 Jan 17] Available from: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4091871.
14. Shorter stays in ED health target [homepage on the Internet]. Wellington: New Zealand Ministry of Health; 2011. [cited 2022 Jan 17] Available from: http:// www.moh.govt.nz/moh.nsf/indexmh/ed-target.
15. Weber EJ, Mason S, Freeman JV, Coster J. Implications of England's four-hour target for quality of care and resource use in the emergency department. Ann Emerg Med 2012;60:699–706.
16. Savioli G, Ceresa IF, Bressan MA, Piccini GB, Varesi A, Novelli V, et al. Five level triage vs. four level triage in a quaternary emergency department: national analysis on waiting time, validity, and crowding-the CREONTE (crowding and re-organization national triage) study group. Medicina (Kaunas) 2023;17:781.
17. Boudi Z, Lauque D, Alsabri M, Östlundh L, Oneyji C, Khalemsky A, et al. Association between boarding in the emergency department and in-hospital mortality: A systematic review. PLoS One 2020;15:e0231253.
18. Lauque D, Khalemsky A, Boudi Z, Östlundh L, Xu C, Alsabri M, et al. Length-of-stay in the emergency department and in-hospital mortality: a systematic review and meta-analysis. J Clin Med 2022;12:32
19. Akhtar N, Kamran S, Singh R, Cameron P, Bourke P, Khan R, et al. Prolonged stay of stroke patients in the emergency department may lead to an increased risk of complications, poor recovery, and increased mortality. J Stroke Cerebrovasc Dis 2016;25:672–8.
20. Zhang Z, Bokhari F, Guo Y, Goyal H. Prolonged length of stay in the emergency department and increased risk of hospital mortality in patients with sepsis requiring ICU admission. Emerg Med J 2019;36:82–7.
21. Davis NW, Sheehan TO, Guo Y, Kelly DL, Horgas AL, Yoon SL. Factors associated with emergency department length of stay and in-hospital mortality in intracerebral hemorrhage patients. J Neurosci Nurs 2021;53:92–8.
22. Rose L, Scales DC, Atzema C, Burns KE, Gray S, Doing C, et al. Emergency department length of stay for critical care admissions a population-based study. Ann Am Thorac Soc 2016;13:1324–32.
23. García-Gigorro R, de la Cruz Vigo F, Andrés-Esteban EM, Chacón-Alves S, Morales Varas G, Sánchez-Izquierdo JA, et al. Impact on patient outcome of emergency department length of stay prior to ICU admission. Med Intensiva 2017;41:201–8.
24. Ganjali R, Golmakani R, Ebrahimi M, Eslami S, Bolvardi E. Accuracy of the emergency department triage system using the emergency severity index for predicting patient outcome; a single center experience. Bull Emerg Trauma 2020;8:115–20.
25. van der Wulp I, Schrijvers AJ, van Stel HF. Predicting admission and mortality with the Emergency Severity Index and the Manchester Triage System: a retrospective observational study. Emerg Med J 2009;26:506–9.
26. Pourasghar F, Tabrizi JS, Ala A, Jafarabadi MA, Daemi A. Validity of the emergency severity index in predicting patient outcomes in a major emergency department. J Nurs Midwifery Sci 2016;3:1–7.
27. Aphinives V, Hurst CP, Sriprajittichai P. Factors associated with length of stay of non-trauma patients in the emergency department: A cross-sectional study in thai healthcare setting. J Med Assoc Thai 2017;100:1232–40.
28. Kristensen AK, Holler JG, Hallas J, Lassen A, Shapiro NI. Is shock index a valid predictor of mortality in emergency department patients with hypertension, diabetes, high age, or receipt of β- or calcium channel blockers? Ann Emerg Med 2016;67:106–13.e6.
29. Cannon CM, Miller RT, Grow KL, Purcell S, Nazir N. Age-

adjusted and expanded lactate thresholds as predictors of all-cause mortality in the emergency department. West J Emerg Med 2020;21:1249–57.

30. Dynesen J, Skov MJ, Mackenhauer J, Jessen MK, Liesanth JY, Ebdrup L, et al. The 7-day mortality associated with an early warning score varies between age groups in a cohort of adult Danish emergency department patients. Eur J Emerg Med 2019;26:453–7.

31. The top 10 causes of death [homepage on the Internet]. Geneva: World Health Organization; 2020 [cited 2022 Jan 17]. Available from: https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death.

32. Kwak H, Suh GJ, Kim T, Kwon WY, Kim KS, Jung YS, et al. Prognostic performance of emergency severity index (ESI) combined with qSOFA score. Am J Emerg Med 2018;36:1784–8.

33. Ramzee AF, El-Menyar A, Asim M, Kanbar A, Ahmed K, Daoud B, et al. The impact of emergency department length of stay on the outcomes of trauma patients requiring hospitalization: a retrospective observational study. World J Emerg Med 2023;14:96-105.

34. Jaruwatthanasunthon J, Worapratya P, Piyasuwankul T. Comparison accuracy in mSIRS, NEWS and qSOFA score to triage sepsis patients in the emergency department at a hospital in Thailand. J Health Sci Med Res 2022;4:487-549.