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Impact of implementing five-level triage system on patients outcomes and resource utilization in the emergency department of Alexandria main university hospital

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ABSTRACT

Objective: To investigate impact of five-level triage system on Emergency Department (ED) patients' outcome and resources' utilization.
Design: A comparative observational study (pre-/post-intervention).
Setting: ED of Alexandria Main University Hospital.
Patients: All trauma patients and adult emergencies presented to ED from 1st of September 2021 to 31st of May 2022. Patients who were discharged or left against medical advice were excluded.
Methods: Five-level triage was implemented in 1st of December 2021 using Australasian Triage Scale. Primary outcome was ED mortality, while secondary outcomes were resources' utilization and ED length of stay (LOS). Multivariate logistic regression model for predictors of ED mortality was used.
Results: Totally, 9766 and 22,936 patients were subjected to three- and five-level triaging, respectively. ED mortality dropped from 5.26% to 1.46%. All resources including human factors were less utilized. ED LOS has declined from 170.1 ± 88.7 to 72.00 ± 109.8 min. All changes were statistically significant, $p < 0.05$. Significant predictors of ED mortality were three-level triaging, medical emergencies, initial code-1, time-to-clinical decision > 60 min, >5 differential diagnoses, more interventions, and longer ED LOS with different Odds ratios.
Conclusion: Five-level triaging reduced rates of mis-triaging, ED mortality, resources' utilization, and ED LOS.

KEY FINDINGS
- Physician-led five-level triage system significantly improved ED mortality.
- Five-level triage significantly reduced resources' utilization including human factors and ED Length of stay.
- Rates of mis-triaging and crowding dropped with reassessment and allocation of more treatment areas.

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1. Introduction

An effective triage classifies patients who present to the emergency department (ED) into groups after immediate assessment to ensure that patients with life-threatening problems receive immediate intervention [1,2]. The Airway, Breathing, Circulation, Disability, and Exposure (ABCDE) approach is used to assess all patients in ED. This approach allows treating life-threatening problems before moving to the next part of assessment and to assess the effects of treatment with every step [3,4]. Under-triage is the allocation of a triage category of a lower acuity than indicated by the patient's condition, creating a potential for patients to deteriorate whilst waiting. Over-triage is the allocation of a triage category of a higher acuity than indicated by the patient's condition, leading to consumption of resources [5,6].

Worldwide, the triage process entails two main systems, three- and five-level triaging. Three level triage is suitable in low volume ED settings. Currently, five-level triage systems are the most widely adopted in high volume EDs, especially in developed countries [7,8]. National Early Warning Score (NEWS) has been developed and modified to NEWS-2 for reassessment to detect deteriorating patients after initial assessment [9,10].

Alexandria Main University hospital (AMUH) is the only university hospital serving tertiary medical service to a huge sector of population. Physician-mediated three-level triage system was used. Triaging was

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lengthy, and most of the patients were triaged as urgent cases that made observation rooms the most overwhelmed areas, leading to missing cases or under-triaging others, especially in lacking a system for reassessment. Decision for implementing physician mediated five-level triage system was taken. Time for reassessment was strictly defined using NEWS. Final disposition of patients from the ED has been facilitated through revision of hospital admission criteria and formulation of 50 algorithms of clinical pathways in the ED.

Aim of this work was to assess impact of implementing five-level triage system compared to previously implemented three-level triage system on patients' outcomes and resources' utilization.

2. Patients and methods

This was a comparative observational study (pre-/post-intervention) between two groups of patients before and after implementing five-level triaging system. Study was performed to evaluate impact of five-level triaging in the ED on patients' outcomes, mortality, resources' utilization, and LOS. Informed written consent was taken from all patients' next of kin according to Helsinki declaration before enrollment into the study. The study was approved by the local ethical committee of Alexandria Faculty of Medicine (protocol code: 0201552, date of approval: NaN Invalid Date).

Eligible patients were those who attended ED of AMUH from 1st of September 2021 to 30th of November 2021 and had been assessed using previously implemented three-level triaging system **(group I)** and patients who attended from 1st of December 2021 to 31st of May 2022 and were assessed using five-level triaging system (**group II**). Local authority of AMUH allowed for a 3-month transitional zone to switch from three- to five-level triaging system. Current study included patients during this transitional zone and patients in the subsequent three months. All trauma patients in all age groups and adult surgical, and medical emergencies were included into the study. Patients who were Discharged Against Medical Advice (DAMA) or Left Against Medical Advice (LAMA) before final disposition from ED were excluded.

This study was conducted in AMUH. It is the only university hospital serving tertiary medical service across four governorates. In addition, it receives primary ambulance referral three and half days per week. AMUH receives around 120,000 patients annually. About 50,000 of them visit the ED. 60% of them are admitted to different departments inside the hospital and the rest receive full medical care in the ED to be discharged home or referred to our specialized clinics. AMUH provides multidisciplinary care around the clock with a total bed capacity of 1736 beds including fully equipped 202 intensive care unit (ICU) beds, 91 intermediate care beds, 56 operating theatres, 21 emergency dialysis beds, and 49 ED beds.

Physician-mediated three-level triage system had been used for screening patients in the ED. Upon implementing five-level triaging system with introduction of NEWS for reassessment using definite timeframes in more treatment areas, senior physician-mediated triaging continued. Remaining ED physicians were distributed to be responsible for different treatment areas. 24-h working shifts were not allowed among residents to ameliorate physicians' burnout.

AMUH ED is divided into three major units: Emergency Casualty Unit (ECU), Emergency Surgical Unit (ESU), and Emergency Medical Unit (EMU). ECU was our study location where it is further subdivided into registry office for patients' registration immediately upon patients' arrival, 8-bed room for triaging, 10 critical beds for triage level-1 (previously known as resuscitation room), 12 emergency beds for triage level-2 (previously known as observation rooms), 6 urgent beds for triage level-3 (previously known as examination rooms), 4 semi-urgent beds for triage level-4 (previously not defined), 5 non-urgent beds for triage level-5 (previously not defined), and 4 fully equipped beds for minor procedures.

Secondary disposition inside the ED included 28 ICU beds and 56 emergency beds in both ESU and EMU. Trauma, acute chest pain, and acute stroke had special fast track access to secondary disposition areas. Toxicological emergencies were triaged through a separate pathway to Alexandria Poisoning Center (APC) inside the hospital. Pediatric emergencies are being treated in other specialized university hospitals. Moreover, during COVID-19 pandemic, there was a separate external pathway for triaging, assessment, and management, till clearance or confirmation of infection for further advanced medical service in isolated areas.

Patients were registered then triaged by one senior ED resident physician (at least 2-years' experience) and at least four house-officers who were pre-trained and supervised. Patients were immediately assessed on arrival according to their level of acuity using ABCDE approach and treated in order of their clinical urgency to allow for patients' allocation to the most appropriate assessment and treatment area taking into consideration the principle of treating life-threatening problems before moving to the next part of assessment and to assess the effects of treatment with every step [3,4].

Patients in Group II (five-level triage system) then were transferred to level 1 for critical conditions that need immediate simultaneous assessment and treatment, level 2 for emergency conditions where assessment and treatment should be done simultaneously within 10 min, level 3 for urgent conditions within 30 min, level 4 for semi-urgent conditions within 60 min, and level 5 for non-urgent conditions within 120 min [5,8,11].

National Early Warning Score (NEWS) was used for timely reassessment to detect deteriorating patients in five-level triage after initial assessment until their final disposition from ECU. Illustrative charts for NEWS score have been posted in different treatment areas in ED to facilitate implementation and timely action plan according to clinical updates for each patient. Of note that when in doubt about patient's triage level, patient was transferred to higher level of triage according to the principle of over-triaging is better than under-triaging [9].

Patients in Group I (three-level triage system) had been categorized into three categories: immediate: for patients who require life-saving interventions who were directed to the resuscitation room; urgent: for patients with emergency but not life-threatening conditions who were directed to observation rooms; and non-urgent: for patients who could wait according to their management plan decisions in the examination rooms [7].

Management in the ED was guided by the formulated 50 clinical pathways (algorithms) to facilitate timely proper disposition from ED through one-way valve pathways. Time-to-clinical decision was the time taken from patient's admission till a clinical decision was made. Critical cases could have their decisions immediately, while stable cases were expected to have relatively delayed decisions. Final disposition of patients from the ED has been facilitated, so that each level has certain area of intra-hospital admission after revision of hospital admission criteria.

Assessment of resources' utilization included consultations (according to predefined DDs), laboratory work-up, radiological studies, treatment categories given, and interventions done. A laboratory testing center was dedicated to the ED. In addition to electrocardiogram (ECG), the allowed bundle consisted of arterial blood gases, complete blood count, random blood sugar, renal function tests (urea and creatinine), electrolytes (sodium and potassium), coagulation profile (PT, INR, and PTT), and cardiac enzymes (CK-MB and high-sensitivity cardiac troponin). Regarding radiological studies, level 1 and level 2 areas were equipped with bedside echo and ultrasound machines. X-ray, Computerized Tomography (CT) scan, and advanced ultrasound services were located inside the ED. An electric ambulance was dedicated for transporting patients to a nearby MRI facility. Of note, all investigations were not allowed to postpone patients' admission decisions.

Treatment categories given were categorized into intravenous fluids, drugs, blood products, and others (oxygen therapy, nebulizer, oral drugs, topical medications, etc.). Emergency interventions included cardiopulmonary resuscitation (CPR), airway, cardiac, circulatory, and drainage interventions which were done in any treatment area after verification by senior ED resident. Minor surgical interventions were only allowed in the intervention area by relevant specialities.

Emergency department length of stay (ED LOS) was calculated in minutes. It began when patient entered the ED and ended with his disposition. Time end point of the study was patient's disposition from the ECU, either by discharge (home or specialized clinic), intra-hospital admission, ICU admission, or death in the ED.

Data in group I were retrieved retrospectively from medical records, while in group II was prospectively collected by direct attendance. Reviewed data in both groups included ED registry, initial assessment sheets, initial triage level (as determined by ABCDE-driven code), next management area, laboratory and radiological results, list of DDs, consultation reports, progress notes, discharge or referral reports, next location of admission, treatments given, interventions done, and death records. Initial assessment sheet included registry number, name, age, date, time, mode of arrival, chief presenting complaint with limited relevant history, initial triage code for allocation of treatment area (levels: 1–5), expected time for next reassessment (in five-level triage), and treatment measures or interventions initiated.

3. Collected data weregrouped based on triage method and analyzed according to

(1) Baseline patients' characteristics including age, sex, mode of arrival, initial presentation, initial triaging code, final code before disposition from ECU, and number of DDs.
(2) Measures of triaging adequacy including time-to-clinical decision, and rates of over-/under-triaging through comparing initial and final codes for each patient.
(3) Primary outcome was ED mortality and ED patients' disposition.
(4) Secondary outcomes were:
    a. Resources' utilization including consultations, (laboratory and radiological) investigations, treatment categories, and interventions.
    b. ED LOS.

4. Statistical analysis

Data were fed to the computer using IBM SPSS software package version 24.0 [12]. Qualitative data were described using number and percentage. Comparison between different groups regarding categorical variables was tested using Chi-square test. Quantitative data were described using mean and standard deviation for normally distributed data while abnormally distributed data were expressed using median, minimum, and maximum. For normally distributed data, comparison between two independent populations was done using independent t-test, while for non-parametric data used Mann–Whitney U-test to compare between two groups. Significance of the obtained results was quoted as two-tailed probabilities and judged at the 5% level. Multivariate logistic regression analysis was done to identify the possible significant predictors of ED mortality.

5. Results

Flow chart of studied patients was presented in Figure 1. Patients presented during the first three months were 10,738 patients, 9766 of them were triaged using three-level system (group I patients). Patients presented in the subsequent 6 months were 24,404 patients, 22936 of them were triaged using five-level system (group II patients). Rest of patients were excluded.

Age, sex, mode of arrival, and initial presentation were nearly homogenously distributed in both studied groups without statistical significance except for male predominance. Regarding occupation rates and overall triaging adequacy in the ED, in group I, code-1 was initial to 30% and final to 31% of patients. Code-2 was initial to 52.8% and final to 26% of patients. In group II, code-1 was initial to 16.8% and final to 10.84% of patients, while codes-2 and -3 were initial to 8.4% and 6.6% and final to 6.18% and 11.24% of patients, respectively. All changes were statistically significant, $p < 0.05$ (Table 1).

36% of patients in group I had their clinical decision immediately versus 51.6% in group II. 23% of patients in group I had their decision in more than 60 min versus 12% in group II. Regarding DD, < 3 DD was encountered in 47% of patients in group I versus 63.5% in group II. >5 DD was found in 23% of patients in group I versus 9.8% in group II. Differences between both groups were statistically significant, $p = 0.001$ (Table 1).

Table 2 demonstrates adequacy of triaging in individual areas by relating initial and final codes of studied patients. In group I, 57.5% of patients in initial code-1 remained the same and 9.4% of them died. 23.5% and 38.7% of patients in code-2 changed to codes-1 and −3, representing under- and over-triaging, respectively. 10.1% and 17.3% of patients in code-3 changed to codes-1 and -2, respectively, representing under-triaging. In group II, 54.0% of patients in code-1 remained the same and 8.3% of them died. 18.1% of patients in code-2 changed to code-1, representing under-triaging and 43.5% of them were over-triaged. 10% of patients in code-3 were under-triaged and 17.4% of them were over-triaged. All changes were statistically significant ($p = 0.001$).

ED mortality was encountered in 1.46% of patients in group II compared to 5.26% in group I. ICU admission was encountered in 23.2% of patients in group II versus 27.3% in group I. More patients in group II were discharged home and admitted to hospital compared to group I. All differences were statistically significant, $p < 0.05$ (Table 3).

Regarding resources' utilization, mean consultations requested in group II (1.67 ± 0.91) were less than group I (1.86 ± 0.93). Mean laboratory investigations in group II (3.03 ± 2.42) were less than group I (3.92 ± 1.96). Mean radiological investigations in group II (1.11 ± 0.85) were less than group I (1.72 ± 0.91). Mean treatments given in group II (1.21 ± 1.08) were less than group I (1.82 ± 1.23). Mean interventions in group II (0.89 ± 0.80) were less compared to group I (1.51 ± 1.17). All differences were statistically significant, $p < 0.05$. Mean ED LOS (in minutes) in group II (72.00 ± 109.8) was significantly shorter than group I (170.1 ± 88.7), $p = 0.0001$ (Table 3).

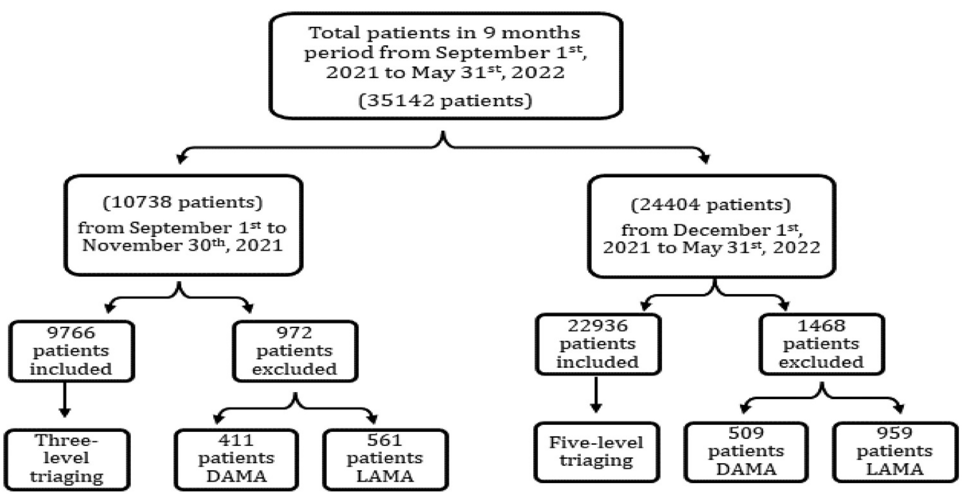

Figure 1. Study patients' flow chart.

Table 1. Baseline patients' characteristics in both studied groups.

	Group I (No = 9766)	Group II (No = 22936)	*p* value
Age (years):			
Range	1.0–98.0	1.0–96.0	*t* = 0.24
Mean ± S.D.	45.7 ± 22.7	45.8 ± 19.7	0.624
Sex:			
Male	5161 (52.8%)	13435 (58.6%)	χ^2 = 19.66
Female	4605 (47.2%)	9501 (41.4%)	0.001*
Mode of arrival:			
By Ambulance	3707 (37.9%)	8873 (38.7%)	χ^2 = 4.02
Ambulatory	867 (8.9%)	1613 (7.0%)	0.211
Private car	5192 (53.2%)	12450 (54.3%)	
Initial presentation:			
Isolated trauma	2051 (21.0%)	5622 (24.5%)	χ^2 = 7.22
Poly trauma	3027 (31.0%)	6811 (29.7%)	0.107
Surgical emergencies	2149 (22.0%)	5108 (22.3%)	
Medical emergencies	2539 (26.0%)	5395 (23.5%)	
Initial Code (ABCDE):			
1	2928 (30.0%)	3851 (16.7%)	0.001*
2	5154 (52.8%)	1921 (8.4%)	(2 # 2,3=
3	1684 (17.2%)–	1512 (6.6%)	0.001*)
4		7819 (34.1%)	(3 # 4,5=
5		7833 (34.2%)	0.001*)
Final Code:			
Died	(ABCDE)	(NEWS)	0.027*
1	514 (5.26%)	336 (1.46%)	0.001*
2	3062 (31.35%)	2486 (10.84%)	(2 # 2,3=
3	2546 (26.07%)	1418 (6.18%)	0.011*)
4	3644 (37.31%)–	2578 (11.24%)	(3 # 4,5=
5		6959 (30.34%)	0.001*)
		9159 (39.93%)	
Time-to-clinical decision:			
ımmediate	3516 (36.0%)	11835 (51.6%)	χ^2 = 89.25
< 30 minutes	1563 (16.0%)	3899 (17.0%)	0.001*
30–60 minutes	2442 (25.0%)	4450 (19.4%)	
> 60 minutes	2245 (23.0%)	2752 (12.0%)	
Differential diagnosis:			
0–2	4590 (47.0%)	14564 (63.5%)	χ2=89.8
3–5	2930 (30.0%)	6124 (26.7%)	0.001*
> 5	2246 (23.0%)	2248 (9.8%)	

Group I: 3-level triaging. Group II: 5-level triaging. Values are presented as number (No.), percentage (%), and mean ± standard deviation (SD). t: student t-test. χ^2: Chi-square test. 2 # 2,3: comparison between code 2 in group I and both codes 2 and 3 in group II. 3 # 4,5: comparison between code 3 in group I and both codes 4 and 5 in group II. p: probability for comparing between both groups. *: significant differences from baseline p ≤ 0.05.

Table 2. Relation between initial and final codes of patients in both studied groups.

		Initial code					χ^2 Test
	Final Code	1	2	3	4	5	*p* value
Group I	Died	275 (9.4%)	139 (2.7%)	100 (5.9%)			
	1	1683 (57.5%)	1209 (23.5%)	170 (10.1%)	-	-	
	2	441 (15.1%)	1813 (35.2%)	292 (17.3%)			73.7
	3	529 (18.1%)	1993 (38.7%)	1122 (66.6%)			0.001*
Group II	Died	318 (8.3%)	18 (0.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
	1	2079 (54.0%)	348 (18.1%)	59 (3.9%)	0 (0.0%)	0 (0.0%)	
	2	602 (15.6%)	719 (37.4%)	92 (6.1%)	5 (0.1%)	0 (0.0%)	
	3	634 (16.5%)	720 (37.5%)	1098 (72.6%)	125 (1.6%)	1 (0.0%)	
	4	190 (4.9%)	83 (4.3%)	213 (14.1%)	6426 (82.6%)	47 (0.6%)	674.1
	5	28 (0.7%)	33 (1.7%)	50 (3.3%)	1263 (16.2%)	7785 (99.4%)	0.001*

Group I: 3-level triaging (initial and final codes were based on ABCDE approach). Group II: 5-level triaging (ABCDE-based initial and NEWS-based final codes). Values are presented as number (No.), and percentage (%). χ2: Chi-square test. p: probability for comparing between both groups. *: significant if p ≤ 0.05.

Table 4 represents multivariate logistic regression analysis for predictors of ED mortality as dependent continuous variable versus ICU, hospital admission, and home discharge. The overall model was significant (Chi-square test = 64.0 and *p* = 0.0001). Significant predictors of ED mortality were three-level triage (Odds ratio = 2.2, 95% C.I. = 1.13–4.11), medical emergencies (Odds ratio = 1.92), initial code-1, time-to-clinical decision >60 minutes, >5 DDs, more interventions, and longer ED LOS (Odds ratio = 2.31).

6. Discussion

The study findings can be summarized as senior physician-led five-level triaging reduced ED mortality, resources' utilization, and ED LOS. Local authority of AMUH allowed for a 3-month transitional zone to switch from three- to five-level triaging system. Current study included patients during this transitional zone and patients in the subsequent three months. This is why study duration in five-level triaging system was 6 months compared to 3 months duration in previously implemented three-level triaging system.

Table 3. Outcome measures in both studied groups.

	Group I (No = 9766)	Group II (No = 22936)	*χ2 Test* *p* value
ED mortality	514 (5.26%)	336 (1.46%)	0.027*
Disposition:			
ICU admission	2666 (27.3%)	5321 (23.2%)	0.036*
In-hospital admission	5899 (60.44%)	14321 (62.44%)	0.031*
Home discharge	687 (7.0%)	2958 (12.9%)	0.021*
Resources utilization:			
Consultations:			
Range	0.0–5.0	0.0–5.0	*χ2*=38.5
Mean ± S.D.	1.86 ± 0.93	1.67 ± 0.91	0.01*
Lab. Investigations:			
No lab. investigations	173 (1.8%)	5922 (25.8%)	0.001*
Range	0.0–8.0	0.0–8.0	*χ2*=6.11
Mean ± S.D.	3.92 ± 1.96	3.03 ± 2.42	0.013*
Rad. Investigations:			
No rad. investigations	1296 (13.3%)	6023 (26.3%)	0.006*
Range	0.0–6.0	0.0–6.0	*χ2*=8.71
Mean ± S.D.	1.72 ± 0.91	1.11 ± 0.85	0.001*
ED treatment categories:			
No treatments	171 (1.8%)	4772 (20.8%)	0.001*
Range	0–4	0–4	*χ2*=57.91
Mean ± S.D.	1.82 ± 1.23	1.21 ± 1.08	0.001*
ER interventions:			
No interventions	1667 (17.1%)	6394 (27.9%)	0.005*
Range	0.0–6.0	0.0–6.0	*χ2*=34.79
Mean ± S.D.	1.51 ± 1.17	0.89 ± 0.80	0.001*
ED LOS (minutes):			
Range	10.0–720.0	10.0–420.0	
Mean ± S.D.	170.1 ±88.7	72 ± 109.8	*U* = 84.1
Median	190.0	88.0	0.0001*

Group I:3-level triaging. Group II:5-level triaging. Lab.: laboratory (ECG, CBC, RBS, renal function tests, electrolytes, arterial blood gases, coagulation profile, and cardiac enzymes). Rad.: radiological (X-Rays, ultrasound, echocardiography, computerized tomography studies, and magnetic resonance imaging). Treatment categories: blood products, I.V fluids, I.V drugs, and others. Interventions: CPR, cardiac, airway, circulatory, drainage, and minor surgical interventions. ED LOS: emergency department length of stay. Values are presented as range, mean ± standard deviation (SD), median, number (No.), and percentage (%). χ2: Chi-square test. U-test: Mann-Whitney U-test. p: probability for comparing between both groups. *: significant if p ≤ 0.05.

Five-level triaging is appropriate for our large volume ED. Lam et al. [13] in their study concluded that three-level triage system is appropriate for low-volume EDs. Christ et al. [14] found that five-level triage is superior to three-level system, as it can assess severity of different patients' conditions and can be used to arrange treatment priorities in German EDs.

Senior physician triaging had been used during implementation of three-level triaging system in our hospital. This was useful in picking up critically ill patients without delays and anticipating patients prone to bad clinical courses. Upon implementing five-level triaging system with introduction of NEWS for reassessment using definite timeframes in more treatment areas, senior physician triaging continued with more confidence in reassessment process.

In favor of this, Abdulwahid et al. [15] in their systematic review and meta-analysis of comparative studies concluded that senior physician triage can be effective to improve ED performance. Jeyaraman et al. [16] reported that primary healthcare professionals-led triage interventions improved ED patient flow outcomes with significant decrease in ED LOS. Travers et al. [17] concluded that placing a senior ED physician with the triage nurse reduced waiting times for ambulatory patients.

Patients who were DAMA and LAMA were excluded from the study as they did not continue management in the ED. Crowdness is a major factor for occurrence of DAMA and LAMA. Another factor for dissatisfaction is that patients attending EDs commonly cite urgency and severity of their condition as the main reason to be seen first upon arrival. This is not the concept with ED physicians. Of note was the drop in percentage of these patients from 9% to 6% with five-level triage system. This may be attributed to better communication with patients after reallocation of treatment areas and redistribution of ED physicians.

Matching with our findings, Toloo et al. [18] investigated discrepancy between triaging priorities and patients' expectations and recommended inclusion of the patient's opinion into the triage process to prioritize resources in accordance with patients' urgency and to balance satisfaction with concepts of proper triaging. Sember et al. [19] explored efficacy of adding physician in triage, to limit rate of DAMA and LAMA. They found that rate of DAMA and LAMA dropped from 5% to 1%.

All age groups were homogenously represented in both groups of our study. Male sex significantly predominated in both groups as more than half of patients were presented with isolated or polytrauma. More than 50% of patients in both groups arrived at

Table 4. Multivariate logistic regression analysis for predictors of ED mortality.

	Standardized B Coefficients	Odds ratio	95.0% C.I.	*p* value
Type of triaging:	0.506			
Three-level		2.20	1.130–4.11	0.004*
Five-level		1		
Age	0.231	1.01	0.57–1.76	0.566
Sex:	0.205			
Male		1.010	0.35–1.11	0.584
Female		1		
Mode of arrival:	0.084			
Ambulance		1.62	0.85–3.08	0.089
Ambulatory		1		
Private car		1.10	0.63–1.83	
Initial presentation:	0.241			
Isolated trauma		1		
Poly trauma		1.03	0.68–2.22	0.261
Surgical emergencies		1.14	0.43–2.02	0.115
Medical emergencies		1.92	0.71–3.68	0.021*
Initial Code:	0.106			
1		2.33	1.16–5.22	0.005*
2 (2–3)		1.15	0.76–2.00	0.172
3 (4–5)		1		
Time-to-decision:	0.108			
Immediate		1		
< 30 minutes		1.10	0.66–1.85	0.223
30–60 minutes		1.21	0.513–2.00	0.107
> 60 minutes		2.27	0.96–4.62	0.007*
No. of D.D.:	0.207			
0–2		1		
3–5		1.02	0.62–1.72	0.236
>5		2.33	1.21–4.87	0.008*
No. of consultations	0.0712	0.96	0.33–1.06	0.074
No. of laboratories	0.128	1.02	0.56–2.02	0.069
No. of radiologies	0.233	1.07	0.76–1.52	0.231
No. of treatments	0.224	0.87	0.656–1.57	0.229
No. of interventions	0.405	1.94	0.917–3.26	0.015*
ED LOS (in minutes)	0.062	2.31	1.41–4.67	0.008*

ED mortality was the dependent continuous variable versus discharge, hospital, and ICU admission. The overall model was significant (Chi-square test = 64.0 and p = 0.0001). No.: number. D.D: differential diagnoses. ED LOS: emergency department length of stay. C.I.: confidence interval. *: significant differences from baseline p (probability) ≤ 0.05.

the ED by private car (self-referral). This may be explained that lack of confidence to referring hospitals made patients less compliant to ambulance transfer regulations leading to more self-referral by private car.

Trauma in the current study was the initial presentation of more than half of patients in both groups. It deserves mentioning that for medical concerns and to ameliorate effect of crowding, trauma, acute chest pain, and acute stroke had special fast track access to secondary disposition areas for further management. Of note, patients stayed more than an hour in the ED before disposition in spite of such fast track. This could be attributed to the time taken by senior ED physician for assessment, stabilization, and work-up before disposition.

There is a number of benefits associated with ED fast track including reduced ED LOS, cost reduction, and increased patient satisfaction. In accordance with such findings, Considine et al. [20] found that ED fast track decreased ED LOS for non-admitted patients without compromising ED LOS for other patients. Cleak et al. [21] investigated efficacy of medical assessment units as secondary disposition areas to improve flow of medical emergencies. They concluded that interaction between health care givers and the implemented administrative system may be crucial for proper patients' flow.

Patients in the present study were triaged into corresponding treatment areas in the ED using initial triaging code. Previously implemented system was limited to three treatment areas. More than 50% of patients in group I were located in level 2 in spite of limited bed capacity and huge number of patients leading to overwhelming problems. On the contrary, five-level triaging system allowed for more treatment areas. 17% of patients in group II were level 1, only 15% were located in levels 2 and 3, and most of patients were located in levels 4 and 5. Timely reassessment was done using NEWS score.

In order to compare occupation rates in different treatment areas between three- and five-level triaging systems, and for statistical reasons, current study incorporated emergency and urgent areas (levels 2 and 3) in group II to be compared to urgent area (level 2) in group I, while semi- and non-urgent areas (levels 4 and 5) in group II were compared to non-urgent area (level 3) in group I. Occupation rates in critical area dropped by 50%, while occupation in emergency and urgent areas dropped by 28%. Such a significant decline in occupation rates in these important areas has participated in less crowdness, better medical service, and accordingly more patient satisfaction.

When relating initial and final codes to measure accuracy of triaging in group I, more than half of patients in urgent and non-urgent areas were under triaged, and nearly 40% of urgent cases were over triaged. Of note that mortality in urgent and non-urgent areas was nearly equal to critical cases. In group II, significantly lower mortality was encountered and was mainly confined to critical area (only 0.9% of emergency cases). Less than half of patients in critical area were reallocated to other areas after stabilization. Only 18% and 3.9% of emergency and urgent cases, respectively, were under-triaged, while no cases in semi- or non-urgent areas were under-triaged.

In accordance with our findings, Najafi et al. [22] explored rates of mis-triage in traumatic patients. They found that under-triage ranged from 1 to 71.9% and over-triage ranged from 19 to 79%. The highest rate of mis-triage occurred among moderately ill who constitute the majority of trauma patients and are more likely to deteriorate. El-sayed et al. [23] compared efficiency of Australasian Triage Scale (ATS) versus the Emergency Severity Index (ESI) triage system in Port Said General Hospital, Egypt. They found significant mis-triage according to ESI in different urgency levels compared to final outcome, which was not the case with ATS.

Another study by AlSerkal et al. [24] found that overall triage accuracy was 41.6%, with a positive association with increasing severity of illness. Ebrahimi et al. [25] found that rate of adequate triage decisions was 60.8%. Over-triage was 20.7% and under-triage 18.5%. Lee et al. [26] used artificial intelligence (AI) to predict level-3 patient outcomes using available data in most ED triage systems. Eleven variables were used for data analysis to develop a prediction model for hospital admission using neural networks and machine-learning methodologies. This model performed better in the non-traumatic adult.

Present study demonstrated that time-to-clinical decision was significantly shorter in five-level triaging (group II). In three-level triaging, clinical decisions needed time for physicians to examine patients in overcrowded observation and examination areas without predefined timeframe. Instead, personal experience of ED physicians to pick up deteriorating patients was the main determinant of clinical decisions. In five-level triaging system, NEWS score charts were promulgated opposite each treatment area for definite timeframes and parameters for reassessment. Maximum time allowed to delay patients' decisions was predefined and announced to patients in a belief that proper and timely communication with patients will decrease their complaints, make them accept waiting time, and ameliorate effects of crowding. This was important for best medical service and more patients' satisfaction. Such timeframe may be shorter according to patients' flow among each category, as less workload helps more rapid decisions.

Challenges and barriers which affect clinical decision-making was explored by Bijani et al. [27]. They found that knowledge, experience, and skills contributed to proper clinical decisions. Teamwork and time management could prevent disorganization in overcrowded ED. Professional factors, organizational management, and ethical matters constituted the other major factors which influenced clinical decision-making of ED personnel at the scene of accidents and determined the quality of their clinical performance.

In current study, ED mortality and adequacy of proper patients' disposition from ED were our primary outcome measures to judge efficacy of triaging. ED mortality dropped significantly (from 5.26% to 1.46%). According to multivariate logistic regression analysis for predictors of ED mortality, significant predictors were three-level triaging, medical emergencies, initial code-1, time-to-clinical decision >60 min, >5 differential diagnoses, more interventions, and longer ED LOS. Implementation of five-level triaging system could decrease ICU admission rates from the ED with higher percentages of home discharge and in-hospital admissions.

In accordance with our findings, Alharbi et al. [28] in their study found a significant reduction in mortality following introduction of a trauma system. They concluded that survival of traumatic injured patients varied according to the stage of system development in which the patient was treated. Arvig et al. [29] in their study about chief complaints, underlying diagnoses, and mortality in adult, non-trauma ED visits reported that short-term mortality was more associated with patient-related factors than with the primary presenting complaint.

Another similar study by ElBaih et al. [30] assessed patients' outcomes after implementing adult version of South African Triage Scale (SATS) in ED of Suez Canal University Hospital, Egypt. Their treatment areas were confined to triaging, resuscitation, observation, and trauma areas; a system which is similar to our previously implemented three-level triaging system. Initial assessment and reassessment were done using triage early warning score (TEWS). They made reassessment after 120 min for all codes after excluding stable and deceased patients. They concluded that SATS was better for assessing patients without missing data and resulted in reduction in ED mortality rate and LOS.

Regarding secondary outcome measures in present study, all resources including human factors were significantly less utilized in five-level triaging. There was a significant decrease in number of consultations when compared to three-level triaging. This may be explained by the smaller number of DDs after revision of hospital admission criteria and formulation of definite algorithms to facilitate timely proper disposition from ED. Laboratory and radiological investigations were less ordered with five-level triaging. Treatment categories and interventions were significantly less in the same manner except for cardiac and drainage interventions.

In accordance with our findings, Singer et al. [31] found that introduction of a laboratory testing facility with rapid response capability dedicated to the ED was associated with shorter laboratory testing time and shorter ED LOS for admitted patients by about 1 h. Zhang et al. [32] examined patient information that was available during the ED triage process, to develop predictive models for using advanced diagnostic imaging (ADI) including computed tomography (CT), ultrasound (US), and magnetic resonance imaging (MRI) in the ED. They concluded that such models can be used to more rapidly identify patients who may require ADI during their ED stay and assist with medical decision-making.

Regarding total ED resource consumption, Müller et al. [33] in their analysis, found that human resources accounted for the largest proportion, followed by radiology, and laboratory work-up. Chief complaint had the highest impact on total resource consumption, followed by performing CPR and ambulance-admission. Abnormal vital signs and triage level were other predictors. Ro young et al. [34] studied the relationship between the triage-based resource allocation and clinical treatment (TRACT) protocol with mortality and LOS in ED using five-level ESI triaging system. They found that TRACT protocol decreased the ED mortality in ESI level-1 group and reduced the ED LOS in ESI levels–2 and −3 groups.

Current study showed that emergency department length of stay (ED LOS) as one of our secondary outcome measures has declined significantly with five-level triaging. It is considered one of the important items to judge efficacy of proper triaging. In favor of this, Elder et al. [35] explored validity of three key strategies designed to promote patients' disposition from the ED. They concluded that advanced nursing practice, physician-assisted triage and medical assessment units are models of care that can positively impact ED disposition. They have been shown to decrease waiting time and ED LOS.

Another study by Yurkova et al. [36] tried to identify factors that affect transfer times between ED and ICU. Delayed patients were identified as those who were transferred after more than 4 h. They found significant problems with the under-triage of critically ill patients, specifically patients with sepsis. Mohr et al. [37] reviewed the literature on frequency of ED boarding among the critically ill, outcomes associated with such boarding, and local strategies developed to mitigate the impact of ED critical care boarding on patient outcomes. They concluded that ED boarding was common and was associated with worse clinical outcomes.

The present study had some limitations. First, we measured ED mortality and total ED LOS without taking into consideration overall mortality or total hospital LOS. Second, medical emergencies held a poor outcome. We think that it would be better to stratify such emergencies to more detailed scenarios to study which cases in-between held the poorest outcomes to secondarily modify clinical pathways in a trial to avoid preventable causes. Third, in group II, we measured ABCDE-driven initial code and NEWS-driven final code without mentioning how many times patients were reassessed using NEWS in each treatment category to reflect how this dynamically changed patients' flow.

7. Conclusion

According to present study, we could conclude that senior physician-led five-level triaging reduced ED mortality, resources' utilization, and ED LOS. Controlled resources and time for assessment decreased rates of mis-triaging, that together with more treatment areas, led to less crowdness and faster patients' flow. Predictors of ED mortality were three-level triaging, medical emergencies, initial code-1, time-to-clinical decision >60 min, >5 DDs, more interventions, and longer ED LOS with different odds ratios.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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