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Predictability of adult patient medical emergency condition from triage vital signs and comorbidities: a single-center, observational study

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Abstract

Background Vital signs and comorbid diseases are the first information evaluated in patients admitted to the emergency department (ED). In most EDs, triage of patients takes place with vital signs and admission complaints only. Comorbidities are generally underestimated when determining the patient's status at the triage area. This study aims to assess the relationship between initial vital signs, comorbid diseases, and medical emergency conditions (MEC) in patients admitted to the ED.

Methods This prospective study was designed as a single-center observational study, including patients admitted to a tertiary ED between 16.06.2022 and 09.09.2022. Patients younger than 18, readmitted to the ED within 24 h, or absence of vital signs due to cardiac arrest were excluded from the study. Vital signs and comorbid diseases of all patients were recorded. The mortality within 24 h, the need for intensive care unit admission, emergency surgery, and life-saving procedures were considered "medical emergency conditions". The role of vital signs and comorbid diseases in predicting emergencies was analyzed by binary logistic regression.

Results A total of 10,022 patients were included in the study; 5056 (50.4%) were female, and 4966 (49.6%) were male. Six hundred four patients presented with an MEC. All vital signs -except diastolic hypertension and tachycardia- and comorbidities were found statistically significant. Hypoxia (Odd's Ratio [OR]: 1.73), diastolic hypotension (OR: 3.71), tachypnea (OR: 8.09), and tachycardia (OR: 1.61) were associated with MECs. Hemiplegia (OR: 5.7), leukemia (OR: 4.23), and moderate-severe liver disease (OR: 2.99) were the most associated comorbidities with MECs. In our study, an MEC was detected in 3.6% (186 patients) of the patients with no abnormal vital signs and without any comorbidities.

Conclusion Among the vital signs, hypoxia, diastolic hypotension, tachypnea, and tachycardia should be considered indicators of an MEC. Hemiplegia, leukemia, and moderate-severe liver disease are the most relevant comorbidities that may accompany the MECs.

Keywords Comorbidity, Emergency, Mortality, Triage, Vital signs

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Background

Over the years, overcrowding in emergency departments (ED) and high patient density have increased the importance of triage in the ED [1]. Triage is the primary tool to assess patients' severity of illness or injury upon arrival to the ED [2]. The purpose of triage is to determine the patient's emergency status and prioritize emergent patients [3]. The critical step of triage is a dynamic process related to various components.

An initial clinical assessment is essential to distinguish the patients and recognize those needing immediate care. According to established international triage scores used worldwide, the parameters of these scores may vary [4]. Common characteristics components are initial vital signs, chief complaint and discriminators, and prediction of resource requirements. However, the joint entity of these scoring systems is vital signs.

Vital signs, with their dynamic and instantaneous variability, are among the simplest and most important information obtained about admitted patients. Vital signs are measurements of the body's most basic functions; they help detect or monitor medical problems or patients' progress. The four classic vital signs are body temperature, heart rate (HR), and blood pressure [5], respiratory rate (RR). These vital signs may significantly impact patient triage scores and clinical outcomes. For example, a patient admitted with a headache may have a different trajectory if their blood pressure is elevated. Similarly, the number of critical vital signs is associated with mortality; as the number of abnormal vital signs increases, mortality rates increase [6].

Besides vital signs, another entity that may be relevant to illness or injury severity and clinical outcome is the comorbid illness of a patient. Likewise, a patient admitted with a headache should be categorized differently if they have a history of a previous brain aneurysm. Management of chest pain varies whether the patient has a cardiac history. Still, comorbidities are not taken into account in the triage of patients in most EDs. It is of vital importance to determine this type of risk in the triage area before examination by the doctor in such patient groups in an overcrowded ED.

This study aims to determine the effect of vital signs and comorbidities on predicting medical emergency conditions (MEC) within 24 h. In this way, the emergency of the patients will be determined accurately and triage of the patient will improve.

Methods

Study type and design

This was a prospective study conducted in an academic ED environment. The study was approved by our institution's Health Research Ethics Board (number: İ04-211-22).

Study setting and population

The prospective observational study was conducted in a large tertiary care hospital with an approximate annual of 50,000 ED admissions. All adult patients admitted to the ED with any complaint between 16.06.2022 and 09.09.2022 were eligible for inclusion. Patients younger than 18 years, re-admitted to the ED within 24 h, and presented with no vital signs due to cardiac arrest were excluded from the study. Informed consent was obtained from patients or legal guardians.

The vital signs recorded from patients were body temperature, heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), respiratory rate (RR), and oxygen saturation (SaO_2). Mindray Beneheart D6 was used for RR, HR, SaO_2, and blood pressure, and Unaan YNA-800 was used for body temperature. These data were recorded in the study form. According to the modified Charlson comorbid index, comorbidities were recorded in the study form as yes/no [7]. Information regarding medical history was obtained from patients' first-degree relatives or informal caregivers when patients were incompetent to give it themselves. A medical emergency condition was defined as mortality within 24 h, need for intensive care unit admission, need for emergency surgery, and life-saving procedures. The MEC, as mentioned earlier, was reviewed through the "Hospital Information Management System" and if one of these four criteria was positive, the patient's status was recorded as in a "medical emergency condition" [3, 8]. Assisted ventilation, intubation, surgical airway, emergent non-invasive positive pressure ventilation, defibrillation, emergent cardioversion, external pacing, chest needle decompression, pericardiocentesis, open thoracotomy, bronchoscopy, intraosseous access, significant intravenous fluid resuscitation, blood administration, control of major bleeding, hemodialysis, and use of medications like naloxone-dextrose-dopamine-dobutamine-noradrenaline-adrenalin-atropine-adenosine were considered as life-saving procedures. Patients who will benefit from the treatments to be applied in the intensive care unit, who cannot be followed and treated outside the intensive care unit, who need mechanical ventilation, who need non-invasive mechanical ventilation, who need continuous invasive hemodynamic monitoring, and who require vasoactive drug therapy were considered as patients who need for intensive care unit admission.

Abnormal vital signs were defined according to the following cutoff values: body temperature > 37.8 C° - body temperature < 35 C°, HR < 60 beats/minute–HR > 100 beats/minute, SBP < 90 mmHg – SBP > 140 mmHg, DBP < 60 mmHg – DBP > 90 mmHg, RR > 24 breaths/minute, and SaO_2 < 94%, RR < 12/minute – RR > 24/minute [9–13].

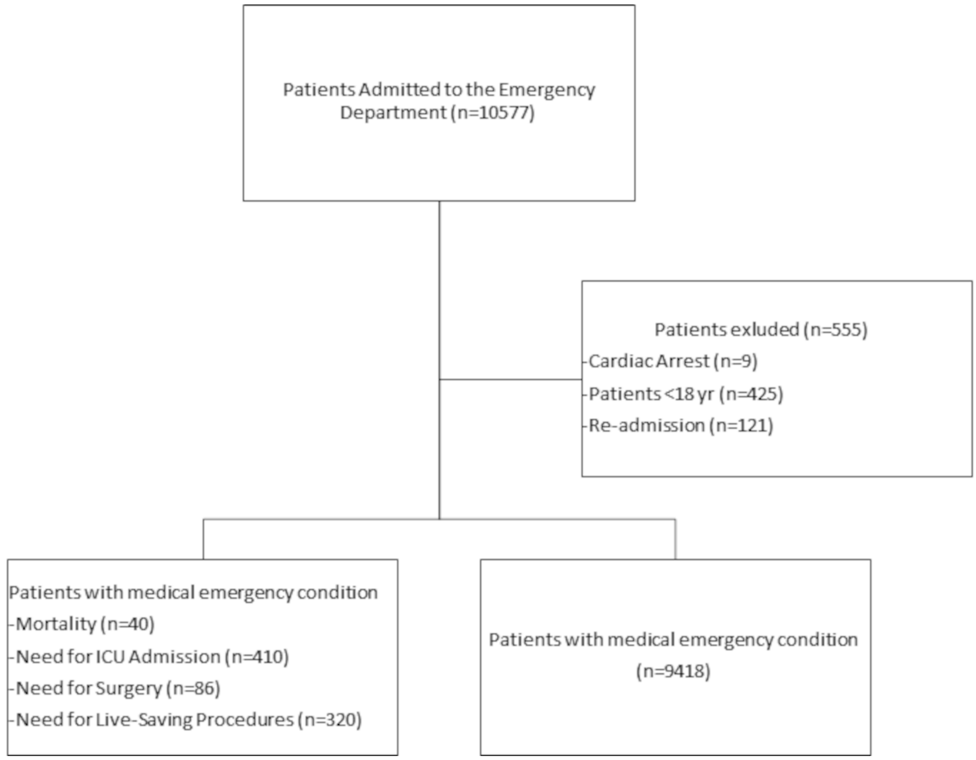

Fig. 1 Flow chart of the study

Table 1 Frequency of medical emergency conditions

Medical Emergency Conditions	*n* *	Percentage	Percentage in all patients (*n* = 10022)
Mortality within 24 h	40	6.6	0.4
ICU requirement	410	67.9	4.1
Emergency Surgery requirement	86	14.2	0.9
Life-Saving procedures	320	52.9	3.2

*: Some of the patients have a coexistence of medical emergency conditions. ICU: intensive care unit

Statistical analysis

All statistical analyses were performed using SPSS 26.0 (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp. 2019) package program.

The mean and standard deviation with frequency and percentage were used as descriptive statistics for normally distributed data. The median and minimum-maximum values were used for non-normally distributed data. A comparison of categorical variables between groups was carried out with a Chi-square test or Fisher's exact test. The relationship between initial vital signs, comorbidities, and MECs was determined using binary logistic regression analysis, and the odds ratio was calculated to determine the factors affecting MEC. A p-value less than 0.05 was considered significant.

Results

The study evaluated 10,577 patients admitted to the ED between 16.06.2022 and 09.09.2022 (Fig. 1). Five hundred fifty-five patients were excluded because of re-admission, age under 18, and cardiac arrest. Of 10,022 patients participating in the study, 5056 (50.4%) were female, and 4966 (49.6%) were male. The median age of the patients was 46 (min-max: 18–104). Hypoxia was detected in 992 (9.9%) patients. 236 (2.4%) patients had diastolic hypotension, while 1691 (16.9%) had diastolic hypertension. Systolic hypotension was observed in 50 (0.5%) patients. 1986 (19.8%) patients had systolic hypertension. Tachypnea and high body temperature were detected in 170 (1.7%) and 593 (5.9%) patients. Pulse counts were outside the normal range in 2077 (20.7%) patients.

In 6360 patients without any comorbidity or MEC, mean DBP and SBP were 80±11.7 mmHg and 127±18.9 mmHg. Median RR, HR, and SaO_2 were 18/min (min-max: 10–29/min), 88/min (min-max: 49–170/min), and 97% (min-max: 75–100%) relatively. The mean body temperature was 36.4±0.6 °C.

At least one MEC was detected in 604 (6%) of all patients (Table 1). At least one of the life-saving procedures was applied to 320 (3.2%) patients. Non-invasive mechanical ventilation, endotracheal intubation, and surgical airway were applied in 44, 58, and 2 patients. Defibrillation, medical/electrical cardioversion, and external pacing were required in 2, 22, and 4 patients, respectively. Fluid resuscitation was performed in 60 patients, blood replacement was performed in 92 patients, vasopressor agents were performed in 66 patients, and hemodialysis was performed in 38 patients. Adrenaline was administered in 64 patients for anaphylaxis. Six patients needed needle/tube thoracostomy, 48 needed bleeding control surgery, and ten needed bronchoscopy. Almost all abnormal vital signs were associated with each one of MEC except hypoxia, heart rate, and body temperature for emergency surgery requirements. These associations are shown in Table 2.

Of the 604 patients with one of the MEC, 206 (34.1%) had hypoxia, and 97 (16.1%) had diastolic hypotension. Elevated DBP was recorded in 112 (18.5%) patients. Tachypnea, bradycardia, and tachycardia were detected in 101 (59.4%), 91 (14.3%), and 188 (31.1%) patients, respectively. Female gender and increasing age were associated with MECs. Fever and SBP were not statistically significant in predicting the MEC. Table 3 shows the frequencies and the odds ratios of vital signs and comorbidities regarding MEC. Hemiplegia, leukemia, moderate-severe liver disease, and any tumor presence had the most significant relationship with MECs. Other comorbidities in the modified Charlson comorbidity index did not significantly predict the MEC at admission.

At least one MEC was detected in 3.6% ($n=186$) of the patients with no abnormal vital signs or comorbidities. As the number of abnormal vital signs increased, the rate of MEC increased ($p<0,01$). The relationship between the number of abnormal vital signs, including the mean arterial pressure and the presence of MEC, is shown in Table 4 .

Table 2 Association between vital signs and medical emergency conditions

	Mortality within 24 h ***n*** **(%)**	**ICU Requirement** ***n*** **(%)**	**Emergency Surgery Requirement** ***n*** **(%)**	**Life-saving Procedures** ***n*** **(%)**
O_2 Saturation				
< 94%	35 (87,5%)	171 (41,7%)	12 (14%)	144 (45%)
≥ 94%	5 (12,5%)	239 (58,3%)	74 (86%)	176 (55%)
p-value	**< 0,01**	**< 0,01**	**0,20**	**< 0,01**
Diastolic Pressure				
Low	22 (55%)	67 (16,3)	9 (10,5%)	74 (23,1%)
Normal	11 (27,5%)	252 (61,5%)	64 (74,4%)	198 (61,9%)
High	7 (17,5%)	91 (22,2%)	13 (15,1%)	48 (15%)
p-value	**< 0,01**	**< 0,01**	**< 0,01**	**< 0,01**
Systolic Pressure				
Low	18 (45%)	34 (8,3%)	5 (5,8%)	35 (10,9%)
Normal	12 (30%)	264 (64,4%)	67 (77,9%)	221 (69,1%)
High	10 (25%)	112 (27,3%)	14 (16,3%)	64 (20%)
p-value	**< 0,01**	**< 0,01**	**< 0,01**	**< 0,01**
MAP				
Low	22 (55%)	55 (13,4%)	4 (4,7%)	55 (17,2%)
Normal	10 (25%)	265 (64,6%)	74 (86%)	213 (66,6%)
High	8 (20%)	90 (22%)	8 (9,3%)	52 (16,3%)
p-value	**< 0,01**	**< 0,01**	**0,03**	**< 0,01**
Respiratory Rate				
> 24/min	22 (55%)	97 (23,7%)	6 (7%)	79 (24,7%)
≤ 24/min	18 (45%)	313 (76,3%)	80 (93%)	241 (75,3%)
p-value	**< 0,01**	**< 0,01**	**< 0,01**	**< 0,01**
Heart Rate				
> 100/min	32 (80%)	140 (34,1%)	13 (15,1%)	118 (36,9%)
60–100/min	8 (20%)	261 (63,7%)	73 (84,9%)	194 (60,6%)
< 60/min	0 (0%)	9 (2,2%)	0 (0%)	8 (2,5%)
p-value	**< 0,01**	**< 0,01**	**0,35**	**< 0,01**
Body Temperature				
≥ 37,6 °C	6 (15%)	43 (10,5%)	2 (2,3%)	28 (8,8%)
< 37,6 °C	34 (85%)	367 (89,5%)	84 (97,7%)	292 (91,2%)
p-value	**0,015**	**< 0,01**	**0,15**	**0,03**

MAP: mean arterial pressure, ICU: intensive care unit

Table 3 Risk factors in patients with the MEC

Significant Risks	Non-MEC *n* (%)	Any MEC *n* (%)	OR	95% CI		*p*-value
				Lower	upper	
CAD	775 (83.6%)	152 (16.4%)	1,566	1,231	1,993	0.000
PVD	234 (85.4%)	40 (14.6%)	1,530	1,023	2,288	0.038
CTD	288 (89.4%)	34 (10.6%)	1,619	1,066	2,459	0.024
Diabetes Mellitus	1146 (87.3%)	166 (12.7%)	1,318	1,052	1,651	0.016
Hemiplegia	20 (62.5%)	12 (37.5%)	5,378	2,248	12,870	0,000
Moderate-Severe Kidney Disease	276 (80.7%)	66 (19.3%)	1,583	1,139	2,201	0.006
Any Tumor Presence	361 (84.9%)	64 (15.1%)	2,268	1,666	3,088	0,000
Leukemia	46 (85.2%)	8 (14.8%)	4,239	1,935	9,284	0,000
Moderate-Severe Liver Disease	90 (75%)	30 (25%)	2,990	1,857	4,814	0,000
Metastatic Solid Tumor	228 (78.4%)	58 (21.6%)	2,360	1,647	3,382	0,000
Hypoxia	786 (79.2%)	206 (20.8%)	1,739	1,366	2,215	0,000
Diastolic Hypotension	236 (70.1%)	97 (29.1%)	3,718	2,711	5,100	0,000
Diastolic Hypertension	1691 (93.8%)	112 (6.2%)	0.945	0.748	1,195	0.638
Tachypnea	69 (40.6%)	101 (59.4%)	8,090	5,528	11,840	0,000
Bradycardia	78 (85.7%)	13 (14.3%)	1,291	0.662	2,519	0.453
Tachycardia	1798 (90.5%)	188 (9.5%)	1,611	1,309	1,983	0,000

MEC: Medical Emergency Condition, CAD: Coronary Artery Disease, PVD: Peripheral Vascular Disease, CTD: Connective Tissue Disease, OR: Odd's ratio, CI: Confidence interval, p-value < 0.05 was considered significant

Table 4 Abnormal vital findings and medical emergency conditions frequencies

Total Abnormal Vital Findings*	Medical Emergency Conditions		*n* = 10,022	p-value
	None	Any		
0	4991 (96.4%)	186 (3.6%)	5177	< 0,01
1	2213 (94,9%)	120 (5,1%)	2333	
2	769 (88,2%)	103 (11,8%)	872	
3	898 (92,2%)	76 (7,8%)	974	
4	443 (89,3%)	53 (10,7%)	496	
5	97 (71,9%)	38 (28,1%)	135	
6	7 (23,3%)	23 (76,7%)	30	
7	0 (0%)	5 (100%)	5	

* Total number of abnormal vital signs include hypoxia, low/high systolic pressure, low/high diastolic pressure, low/high mean arterial pressure, high respiratory rate, bradycardia/tachycardia, and fever

Discussion

Six hundred and four patients revealed any medical emergency condition after admission. The vast majority of MEC were ICU requirements and life-saving procedures. Among these patients who have any MEC, all abnormal vital signs were associated with mortality, life-saving procedures, and ICU requirements. Hypoxia, heart rate, and body temperature were not statistically significant for emergency surgery needs. As the number of abnormal vital signs increases, the probability of developing MEC increases. Most comorbidities were found statistically significant in terms of any MEC. Hemiplegia, leukemia, moderate-sever liver disease, and metastatic solid malignity were most associated with any MEC.

The measurement, recording, and reporting of vital signs are integral to patient management. These findings vary in disease and provide immediate information for the experienced healthcare professional about the underlying pathology. In addition, comorbidities give information on the patient's prognosis and lead to different ways of patient management. Nevertheless, the importance of comorbidities when combined with vital signs was not noticed sufficiently. In most triage systems, vital signs and complaints are taken into account. The study showed the importance of vital signs such as DBP and comorbidities in determining a patient's emergency status, such as MECs.

The oxygen saturation expresses the percentage of hemoglobin molecules saturated with oxygen. This indicates the state of hypoxemia. Ikram and Pillay showed hypoxia predicts mortality in COVID patients at admission [14]. As in our study, hypoxia carries a risk for mortality, and mortality rates and ICU admission [15] increase as hypoxia deepens [6, 16]. It is a marker for hospitalized patients' intensive care unit (ICU) admission [17]. The low oxygen saturation value before discharge is even significant for re-admission to the ED [9, 12].

Diastolic blood pressure is the resting pressure on the arteries between each cardiac contraction. Low DBP causes high pulse pressure, and increased pulse pressure may indicate arterial stiffness, often due to aging or cardiovascular disease. High diastolic blood pressure causes low pulse pressure, which may be a marker of poor heart function with decreased cardiac output. Although not mentioned in the literature, which is similar to our study [9, 12, 16], low DBP can predict mortality [6]; it has even been shown that low DBP is a better predictor of cardiac arrest [18] and mortality from respiratory failure, especially from COVID-19 infection [14]. Even though high DBP was not found significant in predicting the emergency status in the study, Bleyer et al. showed an increase in mortality at values of 120–130 mmHg and above for DBP, unlike our study [6]. Systolic blood pressure is the maximum pressure on the arteries during left ventricular contraction. Low SBP causes low pulse pressure, a marker of poor heart function, and reduced cardiac output. On the other hand, high SBP may be due to renal, endocrine, intracranial, pregnancy-related, and cardiovascular causes, as well as essential. In the study, low and high SBP was statistically significant in predicting the MEC. Similar to our study, low SBP was a risk factor for mortality, and mortality rates increase as the low SBP deepens [6, 16]. The low SBP before discharge resulted in re-admission to the ED and mortality [9, 12]. An increase in mortality was found at values of 200 mmHg and above for SBP [16]. Contrary to our study, Ikram and Pillay said high systolic pressure is not statistically significant for mortality. Besides, this study was on COVID-19 patients, and mortality was caused by respiratory problems mainly.

Respiratory rates vary with age. The average resting RR for adults is 10–20 breaths per minute. An increased number of breaths carries a significant risk for mortality, and mortality rates increase as tachypnea worsens [6, 16]. A high RR before discharge is a good indicator for readmission to the ED. As the number of breaths increases, the transfer rates of hospitalized patients to the ICU and mortality increase [12, 15, 18]. Tachypnea is a good predictor of mortality [14]. Parallel to the previous studies, respiratory rate was associated with each one of the MECs.

Heart rate is an important variable that determines cardiovascular risk. Tachycardia is a resting HR above 100 beats/min in adults. Tachycardias may occur due to physiological processes such as effort, anemia, pain, and anxiety. It may also arise for compensation in pathological processes such as hypoxia, fever, acidosis, hyperthyroidism, shock, and coronary ischemia. A heart rate below 60 beats/minute is bradycardia in adults except for athletes [19]. A high HR is significant for mortality; the mortality rates increase with an increase in heart rate [6, 16]. Tachycardia is a good indicator of in-hospital cardiac arrest, and a high heart rate before discharge increases the re-admission to the ED [9, 12, 18]. While low heart rate was not statistically significant in predicting emergencies in our study, an increase in mortality was found in low heart rates [16]. Nevertheless, Barfod et al. showed no increase in mortality and ICU admission when heart rates were low [15]. Like the literature, tachycardia was a good predictor for emergencies in our study.

Body temperature is a vital sign affected by many internal and external sources. A healthy person's body temperature ranges from 36.5 to 37.8° C. Like the study, Nguyen et al. did not find an increase in re-admission to the ED and 30-day mortality with high body temperature before discharge [12]. However, there are also studies showing an increase in mortality as the body temperature increases, and there is an increase in re-admissions to the ED in patients with high body temperature before discharge [6, 9, 16]. Current findings have not clarified the role of body temperature in predicting an emergency status. However, having a high body temperature was found associated with mortality and ICU requirements in our study.

In our study, there was an increase in MEC probability when the abnormal vital sign number increased. Barfod et al. also showed the total number of abnormal vital signs is important for the prediction of mortality and ICU admission [15].

Bleyer et al. classified the comorbid diseases of the patients as chronic heart failure, chronic obstructive pulmonary disease, cancer, dementia, end-stage renal disease, and other end-stage diseases. Similar to our study, there was no mortality risk in the presence of chronic heart failure or dementia. Still, an increased mortality risk was observed in end-stage renal and other end-stage diseases [6]. It has been shown that the vital signs and comorbidities affect mortality, transfer to the ICU, and the frequency of re-admissions to the ED [6, 9, 12, 16, 17]. As the Charlson Comorbidity index score increases, the probability of mortality increases as well [20, 21]. It is also recommended that comorbidities be used to determine trauma patients' initial triage and prognosis [22]. It is seen that the importance of comorbidities in terms of triage is underestimated, especially in elderly trauma patients [23]. Contrary to the literature, Uslu et al. defined no increase in mortality in elderly trauma patients with comorbidities [24]. Likewise, it is reported that comorbidities should be considered to predict the prognosis after surgery [25, 26]. Even an artificial intelligence-based triage system was created in which comorbidities were encountered [27]. It's obvious that comorbidities increase the burden of illness so as mortality. Although there are similar studies, the difference in the outcome part and the calculation of the emergency risk based on comorbid diseases are the most valuable aspects of the study.

After the current survey, questioning comorbidities in the first triage area has become more important in our practice. The triage officers were informed about the comorbidities that can augment the risk for mortality, and ICU admission.

Limitations

There are some limitations in the study. It was a single-center study with the patient population of a single region. Other limitations in the study are that other early warning systems, triage grading, and re-measurements of vital signs were not evaluated. Moreover, the patients could be separated as traumatic or non-traumatic according to MECs. Another limitation of this study was the measuring of vital signs was not performed by the same person because of the high population.

Conclusion

Hypoxia, low DBP, tachypnea, tachycardia, and some comorbidities are good predictors of an MEC. Adding DBP and comorbidities to the early warning scoring systems should be considered. Healthcare providers should consider that MECs may occur in patients even without abnormal vital signs. While performing triage, the patient should be evaluated as a whole with vital signs, comorbidities, and general condition.

Abbreviations

ED	Emergency Department
MEC	Medical Emergency Condition
OR	The Odd's Ratio
RR	Respiratory Rate
HR	Heart Rate
CCI	Charlson Comorbidity Index
SBP	Systolic Blood Pressure
DBP	Diastolic Blood Pressure
SaO<$_2$	Oxygen Saturation
ICU	Intensive Care Unit

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Author contributions

MY and OP have set up the main idea and hypothesis of the study. MY, ASY, and SG developed the theory and organized the material and method section. MGE and ABO evaluated the data given in the conclusion. MY, ASY, and AK wrote the discussion part of the article, after OP reviewed it, made necessary regulations, and approved it. All authors discussed the entire study and approved the final version of the manuscript.

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Data availability

The datasets generated and/or analyzed during the current study are not publicly available due the patients' files were derived from archives of Hacettepe University but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Ethics Committee approval was obtained before the study to derivate the patient files from the Ethics Committee of Ankara University. (number: İ04-211-22). Informed consent was obtained from patients or legal guardians.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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