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Original Research

# A New Vital Sign in Determining the Triage Category in Emergency Department Presentations: End-Tidal Carbon Dioxide

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**ABSTRACT**

**Objective:** To investigate whether patients' end-tidal carbon dioxide ($ETCO_2$) values measured at the time of their presentation to the emergency department can be used together with vital signs in determining their triage categories and predicting hospitalization.

**Methods:** This prospective, observational, cross-sectional study was conducted between May 1, 2023, and June 1, 2023, at the emergency department of a tertiary hospital. The study included patients aged >18 years who presented to the emergency department and were evaluated to have a triage category of level 2, 3, or 4 according to the five-step triage system. The patients' vital signs were measured at the time of their presentation to the emergency department and the $ETCO_2$ values measured through a nasal cannula were statistically evaluated in terms of their relationship with triage categories and hospitalization indications.

**Results:** A total of 1,100 patients were included in the study. According to the triage category of the patients, the mean $ETCO_2$ values for triage levels 2, 3, and 4 were 27.1±3.6, 30.6±3.1, and 35.4±3.5, respectively, indicating statistically significant differences ($p<0.001$). When the relationship of $ETCO_2$ and vital signs with hospitalization indications evaluated at the emergency department was examined, the area under the receiver operating characteristic curve for $ETCO_2$ was 0.733, which was statistically significant ($p<0.001$).

**Conclusion:** On completion of the study, it was concluded that the $ETCO_2$ values measured at the time of presentation to the emergency department can be a new vital sign that can be used to determine the triage categories of patients and identify those who require hospitalization.

**Keywords:** Emergency triage, end-tidal carbon dioxide, triage category, vital sign, hospitalization

## INTRODUCTION

The increase in the number of patients seeking emergency care and the overcrowded nature of emergency departments make it difficult to provide effective care for critical patients [1]. Therefore, patients presenting to the emergency department are evaluated by grouping them according to the urgency of their conditions [2]. Various triage systems have been developed to perform this categorization, with the most commonly adopted being the Australasian Triage Scale, the Emergency Severity Index, the Manchester Triage Scale, and the Canadian Triage and Acuity Scale [3].

Many triage systems are based on patients' vital signs (VSs) measured at the time of their presentation to the emergency department. VSs are obtained by measuring physiological parameters, such as pulse, blood pressure, respiratory rate, oxygen saturation, and body temperature [4]. In many studies, VSs measured at the time of presentation to the emergency

department in all age groups have been associated with hospitalization requirements and in-hospital mortality [5-7]. VSs are very useful for emergency services since they are obtained using non-invasive techniques. However, the literature suggests that VSs alone may be insufficient for initial patient evaluation [8].

End-tidal carbon dioxide ($ETCO_2$) refers to the partial pressure of $CO_2$ available at the end of expiration, and the monitoring of this parameter provides information concerning the quality of ventilation and perfusion [9]. $ETCO_2$ has been the subject of numerous resuscitation studies. It has been shown that $ETCO_2$ is associated with the quality of resuscitation [10,11]. Due to its relationship with ventilation and perfusion, $ETCO_2$ has also been used in the triage of trauma patients and has been found to be successful [12,13].

Among patients presenting to the emergency department, it is essential to rapidly identify those who are likely to progress into mortality or morbidity, i.e., those who require hospitalization, and provide the appropriate treatment. For this purpose, VSs measurements are performed during triage. However, factors such as the noisy and stressful nature of the emergency department, measurement being dependent on the knowledge and experience of healthcare personnel, drugs used by patients, previous diseases, and age can affect VSs [14,15]. Therefore, there is a need for more objective methods to reliably demonstrate the clinical status of patients at the time of triage. In this study, we aimed to evaluate the relationship of $ETCO_2$, a ventilation and perfusion indicator, with triage categories and determine its ability to predict hospitalization indications in comparison with VSs.

**Main Points;**

- Although ETCO2 measurement is a parameter that is continuously measured during resuscitation, instantaneous ETCO2 measurements can provide information about the global perfusion status of patients.
- In this study, we found that ETCO2 values, which are an informative parameter for the determination of mortality and termination of resuscitation, can be used together with other vital signs to determine the triage category in emergency services.
- If this result can be strengthened by multicenter studies evaluating vital signs and ETCO2 together in emergency services, we believe that triage categories can be determined better.
- A single ETCO2 measurement was included in this study. Also, repeated ETCO2 measurements of patients will provide more reliable results.

## MATERIALS AND METHODS

### Study Design

This prospective, observational, cross-sectional study was conducted between May 3, 2023, and June 1, 2023, at the emergency department of a tertiary hospital. Local ethics committee approval was obtained for the study (ethics committee number: 3/14, date 05/02/2023). The study was carried out in accordance with the tenets of the Declaration of Helsinki. The total number of patient presentations to our emergency department is approximately 223,500/year; however, the number of applications per day varies. Therefore, in order to ensure that the patients to be included in our study were realistic, data collection was performed over one week on a full-time basis, using the number of patients on the same dates in the last two years as a reference.

### Study Population and Patient Selection

At the time of presentation to the emergency department of our hospital, the triage categories of the patients are determined according to the five-step triage system. Very urgent patients who cannot be kept waiting in the emergency department (level 1 triage category according to the five-stage triage system) are provided care in the resuscitation room. Considering that the treatment of these patients is a priority, their $ETCO_2$ values were not measured to ensure that no time was wasted, and therefore these patients were excluded from the study. In addition, patients who do not have an emergency (level 5 triage category according to the five-stage triage category) are provided care in the green zone of our hospital's emergency department. These patients were also not included in the study since they did not require any urgent examination or treatment. All other patients are managed in yellow and red zones according to their VSs, previous diseases, and medical histories and categorized into triage levels 2, 3, and 4. This group constituted the population of our study. We also excluded patients who did not accept to participate in the study or who left the hospital without a doctor's approval while their examination and treatment were ongoing at the emergency department.

Patients aged >18 years who presented to the emergency department over the study period and were classified into triage category levels 2, 3, or 4 were included in the study. During the study period, a total of 1,864 patients were identified having presented to the emergency department and meeting the specified criteria. In five of these patients, the triage category was increased to level 1 because they developed a

cardiopulmonary arrest during their examination and treatment at the emergency department. Therefore, these patients were excluded from the study. A further 226 patients refused treatment or left the emergency department before the end of their examination or treatment. In addition, 148 of the patients did not want to participate in the study, and the triage category of 132 patients was not determined according to the five-triage system; therefore, these patients were also excluded from our study. Lastly, 253 patients whose VSs were not completely recorded, were excluded. As a result of the application of the inclusion and exclusion criteria, a total of 1,100 patients were included in the sample (Figure 1).

**Data Collection and Recording**

At the time of presentation to the emergency department, the reasons for patients' referrals were recorded in patient files by experienced triage nurses with at least three years of professional experience who had attended annual vocational training programs and received training on triage categories. Then, the patients' pulse, blood pressure, body temperature, and oxygen saturation values were recorded. The patients' $ETCO_2$ values (Capnostream-20, Medtronic, Israel) were measured using a nasal cannula and recorded in patient files at the time of presentation.

The triage categories of the patients were determined according to their VSs and complaints, according to the five-step triage system used in the Canadian triage system [16]. Level 1 patients who were very urgent and required simultaneous treatment were evaluated in the resuscitation room. In addition, level 5 patients whose complaints were not urgent and whose VSs were stable were separated to be evaluated in the green zone. The remaining patients were classified into levels 2, 3, or 4 and evaluated in relevant zones. The discharge or hospitalization status of these patients was recorded in their files. Age, gender, VSs, $ETCO_2$ values, triage categories, and outcomes (hospitalization or discharge) recorded in the files of the patients were transferred to the electronic environment.

**Statistical Analysis**

In this study, statistical analyses were performed using the IBM SPSS package program v. 25.0. The Kolmogorov-Smirnov test was used to evaluate the normality of the data distribution. Categorical variables were given as frequency and percentage, and continuous variables as mean and standard deviation. The chi-square test was conducted for the analysis of categorical variables. In the analysis of continuous variables, the Wilcoxon test was used for data showing a normal distribution, and the Kruskal-Wallis test for data that were not normally distributed. The Pearson correlation test was performed for the correlation analysis of the variables. The relationship of $ETCO_2$ and VSs with patient outcomes at the emergency department was investigated with a receiver operating characteristic (ROC) curve analysis, and the area under the curve values were calculated. In all analyses, $P < .05$ was considered statistically significant.

**RESULTS**

The mean age of the patients included in the study was 49.3 ± 18.8 years, and 645 (58.6%) of the patients were female. The mean $ETCO_2$ value was 28.1 ± 3.5. The triage category was level 2 in 148 (13.5%) patients and level 4 in 757 (68.8%) patients. The demographic characteristics of the patients and findings obtained at the time of their presentation to the emergency department are given in Table 1.

**Table 1**. Demographic characteristics of the patients and their findings at the time of admission to the emergency department

| Variables | Median ± SD (min-max), n (%) |
|---|---|
| Age (years) | 49.3 ± 18.8 (18-98) |
| Gender | |
| Male | 455 (41.4%) |
| Female | 645 (58.6%) |
| Systolic blood pressure (mmHg) | 138.6 ± 26.1 (84-253) |
| Diastolic blood pressure (mmHg) | 82.4 ± 15.8 (40-126) |
| Pulse (/minute) | 90.7 ± 16.9 (50-175) |
| Body temperature (C°) | 36.4 ± 0.5 (35.7-39.7) |
| Saturation (%) | 92.7 ± 4.9 (50-100) |
| $ETCO_2$ (mmHg) | 28.1 ± 3.5 (18-38) |
| Triage category | |
| Level 2 | 148 (13.5%) |
| Level 3 | 195 (17.7%) |
| Level 4 | 757 (68.8%) |
| Patient outcome | |
| Discharge | 942 (85.6%) |
| Hospitalization | 158 (14.4%) |

SD: standard deviation; $ETCO_2$: end-tidal $CO_2$

Table 2 shows the comparison of the patients according to the triage category. Accordingly, the mean ages of level 2, 3, and 4 triage categories were 55.3 ± 16.8, 52.4 ± 18.4, and 47.4 ± 18.9 years, respectively, indicating statistically significant differences ($P < .001$). The mean $ETCO_2$ of the level 2, 3, and 4 triage

categories was 27.1 ± 3.6, 30.6 ± 3.1, and 35.4 ± 3.5, respectively, which also statistically significantly differed between the groups (P < .001).

The correlation of $ETCO_2$ with the triage category and other parameters is given in Table 3. Accordingly, $ETCO_2$ was positively correlated with the triage category (P < .001). and saturation at statistically significant levels (P < .001 for both).

Figure 2 presents the correlations of $ETCO_2$ and VSs with patient outcomes at the emergency department. Accordingly, the area under the ROC curve value of $ETCO_2$ was 0.733, which was statistically significant (P < .001). Other parameters, such as pulse, body temperature, and saturation, were also statistically significant in terms of patient outcomes (P > .05) (Figure 2, Table 4).

**Table 2.** Comparison of patients by triage category

| Variables, median ± SD (min-max), n (%) | Level 2 | Level 3 | Level 4 | p value |
|---|---|---|---|---|
| Age (years) | 55.3 ± 16.8 (20-98) | 52.4 ± 18.4 (18-90) | 47.4 ± 18.9 (18-91) | **<.001** |
| Gender | | | | |
| Male | 66 (6%) | 75 (6.8%) | 314 (28.5%) | .460 |
| Female | 82 (7.5%) | 120 (10.9%) | 443 (40.3%) | |
| Systolic blood pressure (mmHg) | 135.8 ± 24 (84-245) | 144.5 ± 28.1 (85-225) | 145.1 ± 30.8 (89-250) | **<.001** |
| Diastolic blood pressure (mmHg) | 82.7 ± 17.5 (40-120) | 85 ± 16.9 (44-126) | 87.7 ± 15.1 (40-125) | **.040** |
| Pulse (/minute) | 89 ± 17.8 (51-141) | 89.7 ± 16.7 (56-156) | 91.3 ± 16.8 (50-175) | .400 |
| Body temperature (C°) | 36.4 ± 0.4 (35.7-38.4) | 36.4 ± 0.6 (35.8-39.7) | 36.4 ± 0.4 (35.7-39.1) | .978 |
| Saturation (%) | 89.5 ± 9.2 (50-100) | 92.9 ± 4.1 (62-99) | 93.2 ± 3.6 (71-100) | **<.001** |
| $ETCO_2$ (mmHg) | 27.1 ± 3.6 (19-38) | 30.6 ± 3.1 (18-36) | 35.4 ± 3.5 (19-38) | **<.001** |
| Patient outcome | | | | |
| Hospitalization | 41 (27.7%) | 36 (18.5%) | 81 (10.7%) | **<.001** |
| Discharge | 107 (72.3%) | 159 (81.5%) | 676 (89.3%) | |

SD: standard deviation; $ETCO_2$: end-tidal $CO_2$

**Table 3.** Correlation of $ETCO_2$ with the triage category and other parameters

| $ETCO_2$ | Age | Gender | Triage category | Saturation | Patient outcome |
|---|---|---|---|---|---|
| r | -0.108 | -0.027 | 0.140 | 0.096 | 0.215 |
| p | **<.001** | .363 | **<.001** | **.001** | **<.001** |

$ETCO_2$: end-tidal $CO_2$

**Table 4.** Results of ROC curve analysis of $ETCO_2$ and VSs in terms of patient outcomes at the emergency department.

| Variables | AUC | SE | 95% CI | P value |
|---|---|---|---|---|
| $ETCO_2$ | 0.733 | 0.023 | 0.687-0.779 | **<.001** |
| Systolic blood pressure | 0.509 | 0.030 | 0.450-0.569 | .733 |
| Diastolic blood pressure | 0.551 | 0.028 | 0.496-0.605 | .069 |
| Pulse | 0.426 | 0.030 | 0.367-0.485 | .008 |
| Body temperature | 0.440 | 0.028 | 0.386-0.495 | .032 |
| Saturation | 0.617 | 0.029 | 0.561-0.673 | **<.001** |

**Note:** ROC: receiver operating characteristic; $ETCO_2$: end-tidal carbon dioxide; VSs: vital signs; AUC: area under the curve; SE: standard error; CI: confidence interval

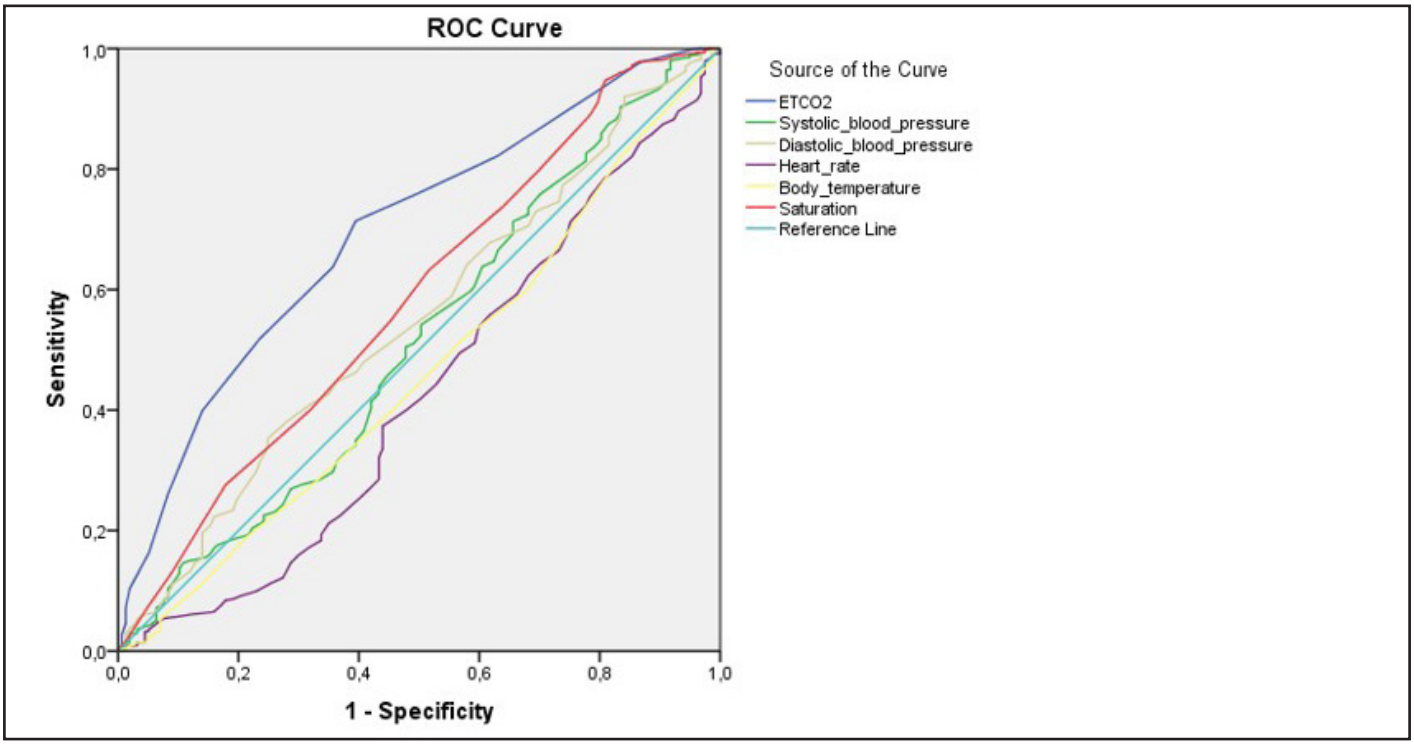


**Figure 1.** Flow chart of patient selection.

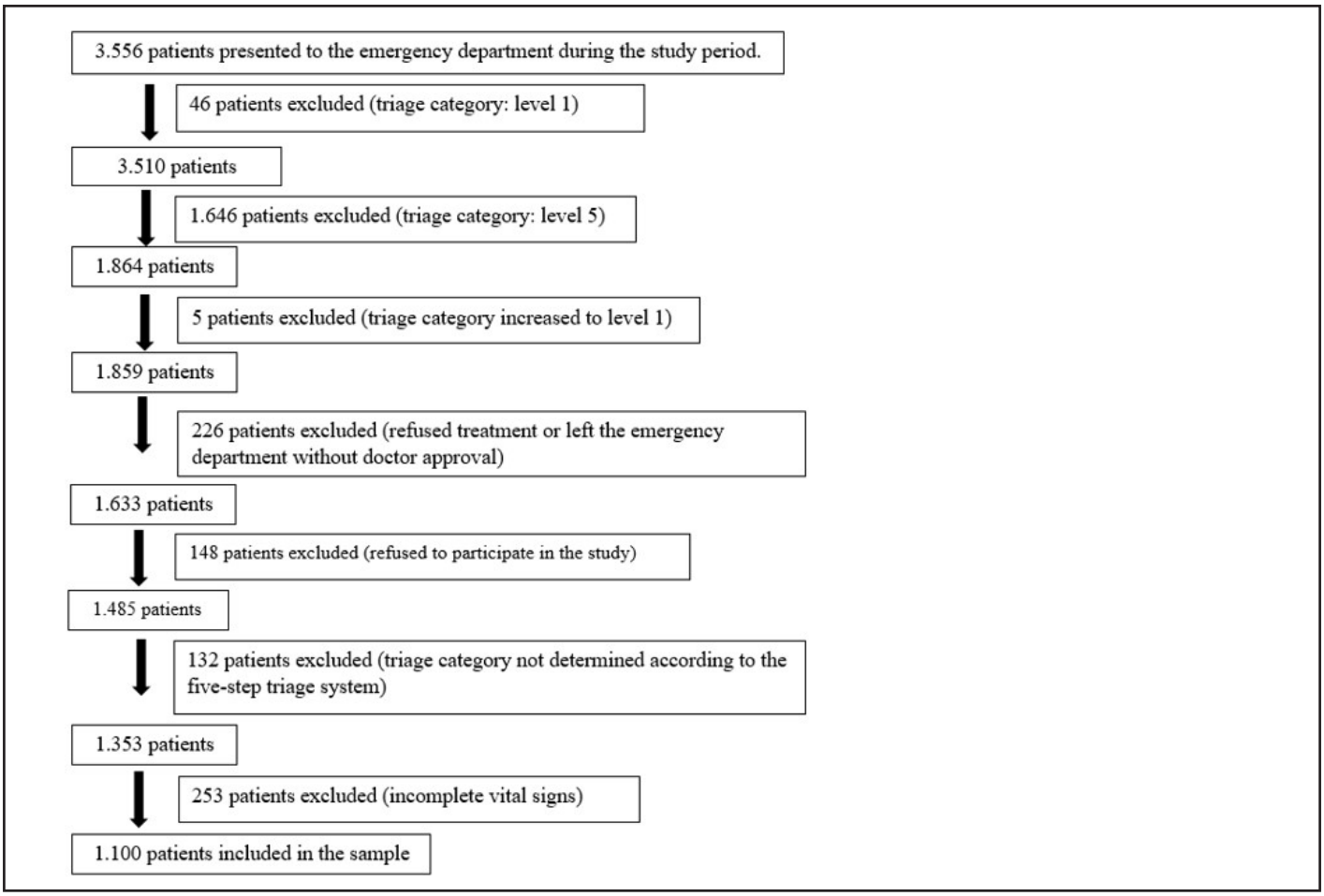


**Figure 2.** Correlation of $ETCO_2$ and VSs with patient outcomes at the emergency department

## DISCUSSION

On completion of this study, it was concluded that the $ETCO_2$ values measured at the time of presentation to the emergency department can be new VSs that can be used to determine the triage categories of patients. In addition, it was determined that $ETCO_2$ values were more valuable than remaining VSs in identifying patients who required hospitalization.

$ETCO_2$ is an important part of the care provided for critically ill patients since it is considered very useful in assessing the quality of ventilation and perfusion of patients. It has been found to be particularly successful in predicting hemorrhagic shock, transfusion and surgical treatment requirements, and mortality in trauma patients [17]. Compared to standard VSs, $ETCO_2$ has been reported to be more successful in predicting mortality in trauma patients [18]. In addition, in a study evaluating patients with sepsis, $ETCO_2$ values were found to be valuable in the evaluation of mortality; however, in that study, $ETCO_2$ values did not have the discriminative ability to identify patients who required hospitalization [19]. It is known that $ETCO_2$ is also significant in the evaluation of the prognosis of patients with dyspnea and even in differentiating between cardiac and non-cardiac dyspnea [20]. Duyan et al. reported $ETCO_2$ to be valuable in differentiating non-cardiac chest pain from unstable angina [21]. Contrary to similar previous studies, in our study, we did not evaluate the relationship between $ETCO_{2,}$ which has an undisputable place in the literature, and hospital mortality. We evaluated the utility of the $ETCO_2$ values measured at the time of presentation to the emergency department in accurately identifying the triage category of patients. In our study, the $ETCO_2$ values of the patients in the level 2 group were lower than those of the patients in the remaining triage categories, since level 2 cases included those that had been exposed to multi-trauma and patients with sepsis, chest pain, and dyspnea. In addition, unlike other studies, when we used $ETCO_2$ to predict the hospitalization requirements of the patients, we determined that the selectivity of $ETCO_2$ was higher than that of standard VSs. This may be related to the low saturation values of the patients in this group.

VSs play an important role in determining the clinical risk of patients in emergency departments or inpatient clinics. However, deteriorations in VSs are often overlooked in the absence of clinical worsening or they are not detected until it is too late for treatment [6]. The main reason for this may be the incomplete recording of VSs, inappropriate response to abnormal values, and the insufficient flow of information on VSs among nurses and doctors [22]. The importance of VSs monitoring in clinical practice is indisputable; however, it remains unclear which VS is more associated with the clinical risk of patients, at what interval VSs should be evaluated, and the best way to monitor them [6]. There are many studies in the literature examining the relationship between VSs measured at the time of presentation to the emergency department and mortality [23-25]. However, only a few studies have explored the relationship between VSs alone and hospitalization indications. For example, in a study by Hong et al., pulse and blood pressure values were found to be unrelated to patients' mortality within the first 72 hours and 30 days or their risk of admission to the intensive care unit [23]. In the same study, it was also reported that the saturation value was valuable in predicting the clinical risks of patients [23]. In a study evaluating one-day mortality in the emergency department, Ljunggren et al. evaluated saturation, systolic blood pressure < 90 mmHg, and heart rate < 50/minute or >110/minute as determinant factors for mortality [24]. In another study, Tsai et al. observed that pulse, saturation, and systolic blood pressure were valuable in predicting in-hospital cardiac arrest among patients visiting the emergency department [25]. In addition, in the three studies mentioned above [23-25], increasing age was found to be associated with mortality. In the current study, we investigated the relationship between VSs and the triage category of patients presenting to the emergency department triage and evaluated the ability of VSs alone to predict hospitalization indications. We found statistically significant differences in the systolic blood pressure, diastolic blood pressure, and saturation values according to age. However, only the saturation value was clinically significant. When the VSs of the patients included in our study were compared in terms of their predictive ability for hospitalization, it was observed that saturation was more successful than the remaining parameters. This may be because the patients included in the study were from a heterogeneous group.

Erroneous measurements that may occur during the VSs evaluation may be due to reasons independent of the patient, such as the external environment and stress factors affecting the VSs, as well as the experience of the practitioner. In addition, VSs can be misleading for emergency services due to patients' chronic diseases, drug use, or older age that may affect these values [14,15]. Therefore, VSs may not provide the necessary assistance in accurately triaging of patients evaluated at the emergency department or rapidly identifying patients who

require hospitalization. Thus, there is still a need for new triage variables to be used for this purpose.

### Limitations

The major limitation of our study is that VSs and $ETCO_2$ values were measured by eight different triage nurses. However, when measuring VSs and $ETCO_2$, great care was taken to record the measurements accurately and in a timely manner. Although necessary training was provided for each of the triage nurses, we did not have the opportunity to check the accuracy of the data recorded. In addition, our study was conducted with a very heterogeneous patient group. Therefore, we were not able to group patients according to their final diagnoses. Furthermore, we excluded level 1 and level 5 patients. Although we consider that the identification of level 1 patients was made accurately, level 5 patients may have been miscategorized by triage nurses. Therefore, these patients were excluded from the study. Additionally, our study was single-center and short research period of time. This may have affected the heterogeneity of errors included in the study. Another limitation is that since VSs and $ETCO_2$ are frequently evaluated as mortality markers in the emergency department, they were not evaluated in our study to avoid repetition of the literature.

## CONCLUSION

We consider that $ETCO_2$ can be used as a new VS to allow the accurate determination of triage categories at the emergency department and prevent long waiting times in the emergency department for patients who require hospitalization. Thus, emergency physicians can make more objective decisions by eliminating external factors that may affect VSs.

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**Ethics Committee Approval**: Local ethics committee approval was obtained for the study (ethics committee number: 3/14).

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