TURKISH JOURNAL OF EMERGENCY MEDICINE

Original Article

Access this article online

Quick Response Code:

Website: https://turkjemergmed.com/

DOI: 10.4103/tjem.tjem_97_25

Emergency department boarding time and in-hospital mortality: A prospective observational study

Vaishnavi Thevrekandy[1]*, Aravind Sreekumar[2], Praveen Aggarwal[3], Jamshed Nayer[3], K. R. Sanith[3]

[1]Department of Emergency Medicine, Malabar Medical College Hospital and Research Centre, Kozhikode, [2]Department of Emergency Medicine, Jubilee Mission Medical College and Research Institute, Trissure, Kerala, [3]Department of Emergency Medicine, All India Institute of Medical Sciences, New Delhi, India

**Corresponding author*

Abstract:

OBJECTIVES: We aimed to study the association between prolonged boarding time in the emergency department (ED) and in-hospital mortality among patients triaged red at presentation.

METHODS: It was a single-center prospective observational study conducted among 300 patients who presented to the ED of a tertiary care teaching institute in North India. The boarding time was calculated as the time interval between the time at which the patient was advised admission and the time at which the patient was admitted to the indoor bed. Risk stratification of patients was done based on National Early Warning Score 2 (NEWS2) at presentation. The patient was then followed up for the duration of their in-hospital course, till discharge or death.

RESULTS: The mean boarding time was higher in patients who died, as compared to those who were alive, but the difference was not found to be statistically significant (14.13 h vs. 11.89 h, $P = 0.053$). Boarding time had a weak discriminatory power on receiver operating characteristic (ROC) analysis (area under the ROC: 0.59: 95% confidence interval [CI]: 0.51–0.67, $P = 0.046$). A boarding time of more than 9.98 h was found to be 70.8% specific and 43.6% sensitive for predicting in-hospital mortality. On logistic regression, an increase in boarding time was found to independently increase the odds of mortality, albeit weakly (adjusted odds ratio: 1.06; 95% CI: 1.00–1.12, $P = 0.03$). A NEWS2 score > 4 at presentation and a requirement of high-dependency unit (HDU)/ıntensive care unit (ICU) admission were found to be significant predictors of in-hospital mortality.

CONCLUSION: Prolonged ED boarding times may be weakly associated with in-hospital mortality. Patients with an increased NEWS2 score at presentation and those requiring HDU/ICU admissions were at higher risk of in-hospital mortality.

Keywords:

Boarding time, emergency department crowding, emergency department, ın-hospital mortality, National Early Warning Score 2 score

Submitted: 10-03-2025
Revised: 16-07-2025
Accepted: 18-07-2025
Published: 01-10-2025

ORCID:
VT: 0009-0001-0497-3016
AS: 0000-0001-6131-1580
PA: 0000-0002-4611-5458
JN: 0000-0002-4343-8809
KRS: 0009-0004-3659-3896

Address for correspondence:
Dr. Vaishnavi Thevrekandy, Thevrekandy House, Pantheerankave, Kozhikode, Kerala, India.
E-mail: vaishnavisajeev6@gmail.com

Introduction

Emergency department (ED) "boarding" of critically ill patients is the holding of patients who have been advised admission in the ED until an inpatient bed becomes available.[1] Prolonged ED boarding times directly result in ED overcrowding. Causes include high daily throughput, limitations in available infrastructure and human resources, and dearth of admission beds. Overcrowding of EDs has been globally identified as a significant challenge for healthcare systems and public health policy

How to cite this article: Thevrekandy V, Sreekumar A, Aggarwal P, Nayer J, Sanith KR. Emergency department boarding time and in-hospital mortality: A prospective observational study. Turk J Emerg Med 2025;25:297-304.

Box-ED section

What is already known on the study topic?

- With increasing boarding times and overcrowding reported in emergency departments (EDs) across the world, multiple studies have been undertaken to investigate the association between boarding times and patient outcomes. The study results have been mixed, with a recent systematic review concluding that there was no significant association between the two.

What is the conflict on the issue? Has it important for readers?

- Most of the studies conducted on the topic of interest have been retrospective in nature. Further, data on ED boarding times and patient outcomes is limited from low–middle-income countries like India, where widespread geographic variations in demographics and healthcare quality further complicate this issue. To our knowledge, this is the first prospective study of its kind evaluating this association within India.

How is this study structured?

- This was a single-center, prospective observational study conducted in the ED of a tertiary care center in North India, recruiting 300 patients triaged red at presentation.

What does this study tell us?

- Prolonged ED boarding times may be weakly associated with in-hospital mortality. National Early Warning Score 2 (NEWS2) score >4 at presentation and high-dependency unit/ıntensive care unit requirements for admission were associated with increased in-hospital mortality. Attempts should be made to identify and mitigate causes of ED boarding, especially among patients with higher severity of illness (NEWS2 score >4) at presentation.

makers, impeding access to quality healthcare. The mean total waiting time for patients visiting the ED of a tertiary care hospital in India, from arrival until transfer to the admitting unit, was reported to be 2.46 h.[2]

The effects of overcrowding are manifold, affecting both patients and healthcare workers.[3] Patients have low satisfaction with care, suboptimal or delayed care, and most worrying of all-increased mortality. Multiple studies demonstrate an association between increased length of stay, in-hospital mortality, and requirement of intensive care unit (ICU) admission.[4,5]

ED overcrowding also results in delays in definitive treatment for life-threatening time-sensitive conditions such as myocardial infarction, higher complication rates in acute coronary syndrome (ACS) and non-ACS-related chest pain, and prolonged disposition times in patients with acute asthma.[6,7] Studies have reported an association between the number of boarding patients in the ED and delay in antibiotics and pain relief, as well as lower patient satisfaction.[8]

Despite these findings, the literature on the impact of ED boarding time on patient mortality shows mixed results.[9,10] These inconsistencies may stem from variations in study designs (often retrospective), differences in hospital protocols, and diverse patient populations. Notably, there is a lack of data regarding the same from resource-limited healthcare systems such as those in India. This is potentially due to multiple reasons, including the relative infancy of emergency medicine as a specialty in many parts of the country, as well as possible underappreciation of boarding times as a concern to patient health and outcomes. In our literature search, we could not come across any studies that aimed to quantify or study this critical issue in an Indian healthcare setting. This study was hence conducted to examine the relationship between boarding times and in-hospital mortality among the patients presenting to the ED of a tertiary care hospital in North India.

Methods

Study design and setting

The study was conducted from September 2021 to February 2023, in the ED of a tertiary care teaching hospital in North India, with a yearly attendance of about 100,000 patients, of which around 2%–5% patients are triaged red at presentation. This was a single-center, prospective, observational study conducted after obtaining ethical approval from the ınstitute ethics committee of All India Institute of Medical Sciences, New Delhi (IECGP-551/September 23, 2021).

Study population

We included patients aged over 14 years who presented to the ED and were triaged red (requiring immediate attention) as per institutional protocol.[11] They were sequentially recruited for the study after inpatient admission orders were received under a specific department following initial resuscitation and stabilization. We excluded patients who:

1. Presented to the ED following trauma
2. Were transferred to other hospitals following stabilization in ED
3. Had a cardiac arrest in the ED after admission was advised
4. Had ST-elevation myocardial infarction or acute ischemic stroke at presentation and were taken up for immediate reperfusion therapy.

Sample size calculation

At the time of designing the study, we could not find any prospective studies evaluating the effect of ED boarding time on in-hospital mortality in the then-reviewed literature. Assuming an outcome prevalence of 50% and an effect size of 0.06, the sample size was calculated to be 267 using the Cochran formula. We intended to recruit 300 study participants to account for missing data as well as to counter a possibly higher Type II error.

Participant recruitment and management

All patients presenting to the ED underwent triage and initial care led by a team comprising trained emergency physicians and nursing staff. These were done as per institutional protocols and were not altered for the purpose of conduct of the study. Following stabilisation, red patients were either discharged or assigned admission under specific departments. Patients who were deemed critically ill even after initial resuscitation and stabilization in the ED were allotted ICU beds. Patients who had attained a certain degree of clinical stability in the ED but required intensive monitoring or were anticipated to have a clinical deterioration were allotted high-dependency unit (HDU) beds. Patients who had improved following their ED stay and were reasonably expected to be free of imminent threats to life, but requiring admission, were shifted to the wards. All decisions were made by the treating team comprising ED physicians on duty as well as the primary admitting department, and were subject to the availability of inpatient beds. Patients were recruited after obtaining informed consent from the patient or their legally authorized representative. Data were collected using a predesigned questionnaire, consisting of demographic details, presenting symptoms of the patient, previous medical or surgical history, physical examination findings, and disposition details. Clinical data collected at the presentation of the patient were used to calculate National Early Warning Score 2 (NEWS2) and then stratify the patient according to the severity of illness [Table 1].[12]

The time at which the patient was advised admission was noted as T_0. The time at which the patient was admitted to the hospital inpatient bed was noted as T_1. The boarding time was calculated as the difference between T_1 and T_0. The patient was then followed up for the duration of their in-hospital course, till discharge or death.

Table 1: Clinical risk stratification based on National Early Warning Score 2 score

NEWS2 score	Clinical risk
Aggregate score 0–4	Low
Red score: Score of 3 in any individual parameter	Low–medium
Aggregate score 5–6	Medium
Aggregate score 7 or more	High

NEWS: National Early Warning Score

Statistical analysis

Data were collected in Microsoft Excel (Microsoft Corporation, 2018), and all statistical analyses were done with IBM SPSS Statistics for Windows (version 25.0, Released 2020, IBM Corp., Armonk, NY, USA). Quantitative variables were presented as mean with standard deviation for normally distributed data and as median with interquartile range, otherwise. Qualitative variables were expressed as counts and percentages. Mean values were compared across groups by ındependent samples *t*-test or Mann–Whitney *U*-test where applicable. Percentages were compared across groups by Chi-square or Kruskal–Wallis tests as appropriate. The receiver operating characteristic (ROC) curve was used to assess the accuracy of boarding time in predicting mortality and to determine valid cutoffs. Logistic regression (LR) was used to identify the predictors of in-hospital mortality, where covariates included age, sex, clinical risk stratification according to NEWS2 score, boarding time, and the unit of admission. All missing data were excluded from the data analysis. A *post-hoc* subgroup analysis was done wherein the patient population was divided into subgroups based on the unit of admittance. LR was used to study the association between boarding time and mortality. Statistical significance was set at a two-tailed $P < 0.05$.

Results

We screened 1982 patients triaged red in our emergency for the purpose of this study. Four hundred sixty-five patients were discharged from the ED, and 1152 patients were referred to other hospitals (mostly due to shortage of inpatient beds) following initial resuscitation and stabilization. We considered 365 patients for inclusion in the study after they were advised admission by a specialty department. Fifty-two patients were excluded: 29 were transferred to other hospitals as inpatient beds could not be arranged despite advice, 21 patients experienced cardiac arrest after admission was advised, and 2 had a history of trauma at presentation. Of the 313 patients recruited, 13 were lost to follow-up (left against medical advice), resulting in a final study population of 300 patients [Figure 1].

Baseline demographics, clinical risk stratification, and unit of admission are summarized in Table 2. The mean age of the study population was 43.8 ± 19.1 years, and 169 patients (56.3%) were male. The mean boarding time was 12.25 ± 6.9 h. A total of 252 patients (84%) survived to hospital discharge.

The mean boarding time was higher in patients who died, as compared to those who were alive, but the difference was not found to be statistically significant (14.13 h vs. 11.89 h, $P = 0.053$). In-hospital

mortality increased significantly across risk categories, from low-risk patients (6%) to high-risk patients (28.3%) ($P < 0.001$). Patients admitted to the HDU had significantly higher in-hospital mortality than those admitted to the ICU or wards (29.5% vs. 5.1% vs. 17.2%, respectively; $P < 0.001$). A detailed comparison is depicted in Table 3.

A ROC curve was plotted to assess the predictive ability of boarding time for in-hospital mortality [Figure 2]. The Area under the ROC (AUROC) curve was 0.59 (95% confidence interval [CI]: 0.51–0.67; $P = 0.046$). A boarding time cut-off of more than 9.98 h had a specificity of 70.8% and a sensitivity of 43.6% for predicting in-hospital mortality.

LR analysis showed that an increase in ED boarding time by 1 h was associated statistically significantly, but weakly, with an increased risk of in-hospital mortality (adjusted odds ratio [aOR]: 1.06; 95% CI: 1.00–1.12; $P = 0.03$). Admission to HDU/ICU and a NEWS2 score >4 (medium/high risk) were also identified as independent predictors of in-hospital mortality. Age and sex were not significantly associated with mortality. The results are summarized in Table 4.

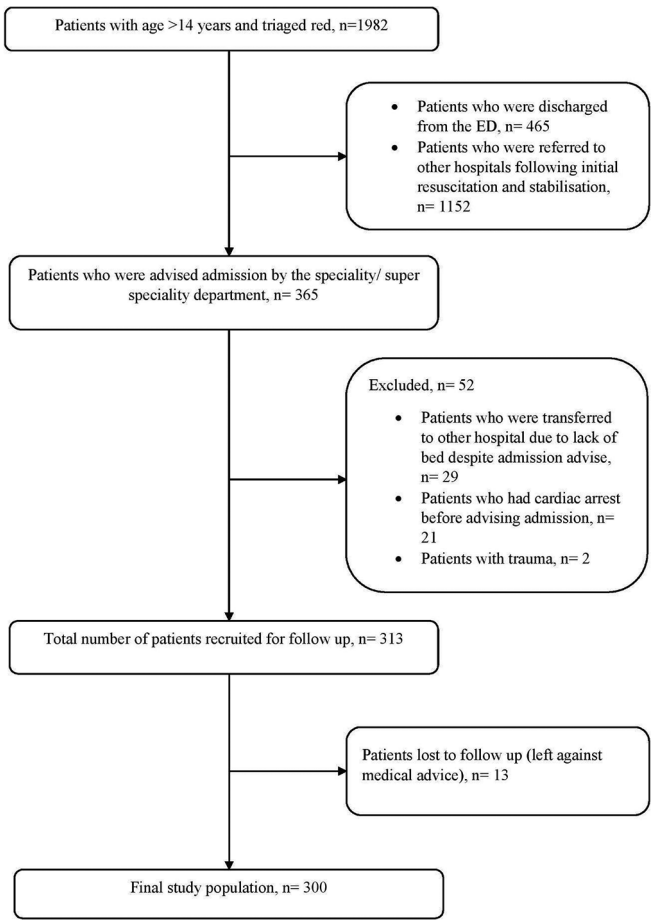

Figure 1: Recruitment of study population

On *post-hoc* subgroup analysis, increased ED boarding time did not significantly affect in-hospital mortality within the individual ward, HDU, or ICU populations [Table 5].

Discussion

Overcrowding of the ED is a rising concern in healthcare facilities, not only in India but globally. This phenomenon adversely affects patient care, impairs ED functioning, and reduces satisfaction among both patients and healthcare providers. Boarding of patients due to the unavailability of appropriate inpatient beds exacerbates this problem.

Various metrics have been used to quantify the length of ED stay. The term "lead time" refers to the duration

Table 2: Patient demographic characteristics, boarding time, and clinical stratification according to National Early Warning Score 2 score (*n*=300)

Parameters	Value (*n*=300)
Age (years)	43.8±19.1
Sex	
Male	169 (56.3)
Female	131 (43.6)
NEWS2 score	
Low risk	148 (49.3)
Low–medium risk	8 (2.6)
Medium risk	63 (21.0)
High risk	81 (27.0)
Unit of admission	
Regular ward	137 (45.6)
High dependency unit	105 (35.0)
ICU	58 (19.3)
Boarding time (h)	12.25±6.9
In-hospital mortality	
Alive	252 (84)
Dead	48 (16)

*Values represented as *n* (%) or mean±SD. NEWS: National Early Warning Score, SD: Standard deviation, ICU: Intensive care unit

Table 3: Comparison of qualitative and quantitative markers with mortality

Parameters	Alive, *n* (%)	Dead, *n* (%)	*P*
Boarding time (h)	11.89±6.8	14.13±7.3	0.053
Age (years)	43.4±19.0	45.8±19.5	0.432
Sex			
Male	141(83.4)	28 (16.5)	0.760
Female	111(84.7)	20 (15.2)	
NEWS2 score			
Low risk	139 (93.9)	9 (6.0)	<0.001
Low–medium risk	7.0 (87.5)	1 (12.5)	
Medium risk	48 (76.1)	15 (23.8)	
High risk	58 (71.6)	23 (28.3)	
Unit of admission			
Regular ward	130 (94.8)	7 (5.1)	<0.001
High dependency unit	74 (70.4)	31 (29.5)	
ICU	48 (82.7)	10 (17.2)	

NEWS: National Early Warning Score, ICU: Intensive care unit

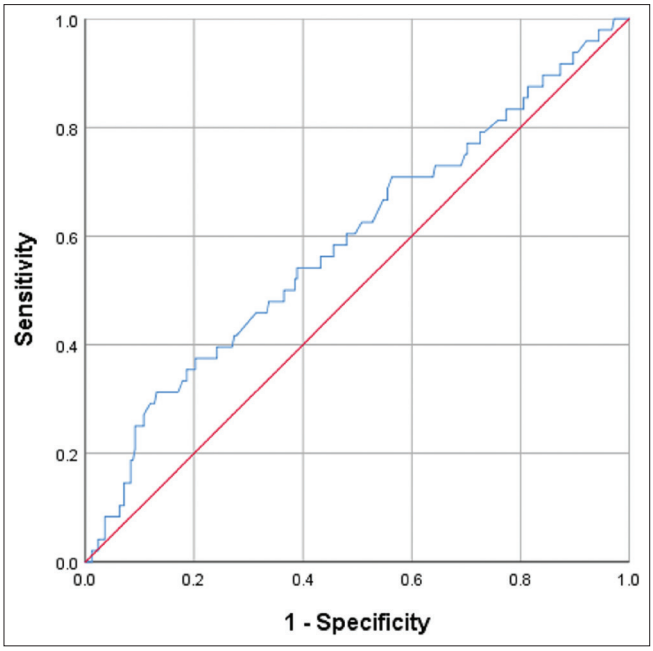

Figure 2: The receiver operating characteristics curve depicting the association between emergency department boarding time and in-hospital mortality

Table 4: Multivariate logistic regression analysis for predictors of in-hospital mortality

Variables	OR (95% CI)	*P*
Duration	1.06 (1.00–1.12)	0.030
Unit of admittance		
High dependency unit	8.073 (3.17–20.54)	<0.001
ICU	4.187 (1.39–12.59)	0.011
NEWS2 score		
Low–medium risk	2.815 (0.23–33.29)	0.412
Medium risk	5.169 (2.00–13.34)	0.001
High risk	4.428 (1.86–10.57)	0.001
Age	1.008 (0.99–1.03)	0.369
Male sex	1.034 (0.51–2.10)	0.927

NEWS: National Early Warning Score, CI: Confidence interval, OR: Odds ratio, ICU: Intensive care unit

Table 5: *Post-hoc* subgroup regression analysis of emergency department boarding time vs mortality based on unit of admittance

Unit of admittance	*n*	OR (95% CI)	*P*
Ward	137	1.062 (0.95–1.19)	0.283
High dependency unit	105	1.053 (0.99–1.12)	0.119
ICU	58	1.074 (0.97–1.12)	0.179

CI: Confidence interval, OR: Odds ratio, ICU: Intensive care unit

from patient arrival at the ED to their admission to the inpatient unit.[13] Singer *et al*. used a similar concept of "boarding time,"[14] which we adopted in this study. We opted for this metric as we believe "lead time" is more susceptible to variation due to institutional protocols, thus potentially affecting the external validity of findings.

In our study, the mean age of participants was 43.8 years, with 56.33% being male. This mean age is considerably lower than that reported in similar studies,[14] possibly attributable to the shortage of inpatient beds for the geriatric population (age >65 years) during the study period. Another consideration is the possibly shorter life expectancy of the population under study, making them more vulnerable as compared to high-income nations.

We found a mean ED boarding time of 12.25 h for patients who required immediate attention as per our center's triage protocol, consistent with findings from studies[13,14] conducted in the U.S. and Canada. However, ED boarding times vary significantly across countries and healthcare systems, influenced by resource availability and admission practices. This heterogeneity is reflected in studies which have described ED boarding times as short as 34 min in Canada.[15] It is however unanimous that boarding times are increasing in EDs around the world. The Royal College of Emergency Medicine reported that approximately 10.2% of all Type I attendances in the United Kingdom (UK) had to wait more than 12 h from decision to admit till admission. This was 4.8 times higher than the figure for 2022.[16] It is crucial to note here that there is a lack of reliable data regarding boarding times in India and other developing world nations. This again signifies that this problem has been less extensively studied in our settings. The issue is amplified even further by the incredible variation in healthcare systems and quality across the length and breadth of a country like India, making generalizations difficult. This signifies the importance of our effort in aspiring to make sense of this problem in India.

The predictive value of boarding time in assessing in-hospital mortality in our study was modest at best. The AUROC of 0.59 indicates limited discriminatory power. Although longer boarding times were statistically associated with increased mortality (aOR: 1.06), boarding time alone lacked sufficient sensitivity and specificity (43.6% and 70.8%, respectively) to serve as a reliable standalone predictor for clinical decision-making or triage.

The relation between boarding times and in-hospital mortality has been demonstrated in multiple studies previously.[14,17] Different cut-offs have been identified in literature to be discriminatory for increased patient mortality. While Jones *et al*. demonstrated an increase in mortality beyond 5 h of ED stay up to 12 h in a retrospective study in the UK,[18] Roussel *et al*. showed that overnight ED stay was associated with a higher mortality in elderly patients.[19] Singer *et al*. concluded that boarding times <2 h were associated with significantly lower in-hospital mortality than those boarded for more than 12 h.[14] On the contrary, multiple studies have demonstrated that there is no quantifiable association between prolonged ED stays and in-hospital mortality,

either.[9,13,20] These variations across multiple studies could be attributed to differences in study populations, study methodologies, patient characteristics as well as institutional protocols. This signifies the difficulty in attempting to summarize the problem, indicating clearly that there is no "One size fits all" approach. Our study was prospective, included only patients categorized red (requiring highest priority) on arrival to the ED, incorporating a patient population with a wide variety of nontraumatic diagnoses. A systematic review concluded that while there was a tendency towards an association between ED boarding and in-hospital mortality, there was no strong evidence to suggest that prolonged ED boarding increases in-hospital mortality.[10] This result closely mirrors our study findings. Most studies included in the review were retrospective in design, a drawback we have aimed to address with our study design. It appears reasonable that while prolonged ED boarding alone may not significantly affect mortality, especially taking into consideration globally increasing quality of ED care, attempts to shorten boarding times may be important for vulnerable and critically ill patients.

We also evaluated the prognostic utility of the NEWS2, which updates the original NEWS2[21] by incorporating new-onset confusion and an alternative SpO_2 scale for Type II respiratory failure.[22] Though NEWS2 has shown predictive utility in conditions such as sepsis[23] and COVID-19,[24] as well as in early triage settings,[25] its ability to predict in-hospital mortality remains debated.[26,27] Our findings are in agreement with previous research suggesting that a NEWS2 score >4 is a strong indicator for ICU admission but less reliable for mortality prediction. A recent meta-analysis by Wei *et al*. echoed this, highlighting NEWS2's high accuracy in early mortality prediction in ED settings but reduced performance for in-hospital mortality.[28] They suggested that serial monitoring might enhance its prognostic value, though this remains understudied for NEWS2. While this has been studied previously with respect to the original NEWS score in patients admitted to general medicine wards,[29] data with respect to NEWS2 score is lacking. With increasing acceptance of NEWS2 score in emergency settings, its utility as a prognostic tool should be studied further in order to facilitate triaging and prioritization of hospital resources. The implications of such research have elevated importance in resource-constrained healthcare systems like India and other low–middle-income countries.

In our *post-hoc* analysis, ED boarding time was not significantly associated with mortality in the critically ill patient group (ICU/HDU) as compared to noncritically ill (ward). The available literature on this topic presents a mixed picture. Verma *et al*. demonstrated an increase in in-hospital mortality for critically ill patients who had a duration of stay >8 h in the ED.[30] It has to be contextualized that our ED has resuscitation rooms with ICU facilities available for temporary holding of patients, thus providing them appropriate interventions even prior to admission, which probably explains our results in any admission subgroup (ICU, HDU, or ward). The limitations inherent to *post-hoc* analyses too must be acknowledged when interpreting these results, rendering them subjective and exploratory at best.

Our results suggest that while clinical severity at presentation and admission requirements posttreatment in the ED significantly impact in-hospital mortality in the patient population, prolonged boarding times may weakly affect the same, especially in high-risk populations. It seems prudent to infer that attempts should be made to reduce ED boarding times, especially in sick patients, within the logistic and resource constraints of the healthcare setup. Further research is required to study the nuances of this association, keeping in mind other confounding factors like patient comorbidities, resource availability, and quality of ED care, which could potentially affect this relation.

Limitations

Our study had a few limitations to consider. We had an assumption sample size of 300 study participants. Though the chosen sample size was considered sufficient to explore the research question in an initial or pilot capacity, this does bring the possibility of a Type II error into question with consequent underpowering of the multivariate LR model. Another key limitation of our study was the absence of confounding factors such as comorbidities and quality of ED care from our LR model. The former was a forced exclusion due to the presence of several pieces of missing data, potentially diluting the results. The quality of ED care and its impact on mortality are extremely variable, depending on multiple factors like the diagnosis, resource availability, and need for definitive care, making it difficult to describe the same quantitatively. Further, changes in the NEWS2 score in the ED were not assessed in the study. This could have been a reflection of the ongoing ED treatment, and could possibly be a better predictor of mortality than single scoring at presentation. Patients who died in the ED after admission advice were excluded from the data analysis, potentially biasing mortality estimates. Subjective protocols regarding triage and patient disposition also affect the generalizability of our results.

Conclusion

Prolonged ED boarding times may be weakly associated with in-hospital mortality. Attempts should be made to identify and mitigate causes of ED boarding, especially

among patients with higher severity of illness (NEWS2 score >4) at presentation.

Author contribution statement

- VT: Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Validation, Writing
- AS: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing – review and editing
- PA: Conceptualization, Investigation, Methodology, Project administration, Supervision, Validation, Writing – review and editing
- JN: Project administration, Supervision, Validation, Writing – review and editing.
- SKR: Data curation, Investigation.

Conflicts of interest

None Declared.

Ethical approval

The study was conducted after obtaining ethical approval from the ınstitute ethics committee (IECGP-551/September 23, 2021), All India Institute of Medical Sciences, New Delhi.

Consent to participate

A written informed consent has been obtained from all the participants.

Funding

None.

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