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ORIGINAL ARTICLE

Emergency department overcrowding and its associated factors at HARME medical emergency center in Eastern Ethiopia

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ABSTRACT

Introduction: Emergency department (ED) overcrowding has become a significant concern as it can lead to compromised patient care in emergency settings. Various tools have been used to evaluate overcrowding in ED. However, there is a lack of data regarding this issue in resource-limited countries, including Ethiopia. This study aimed to validate NEDOCS, assess level of ED overcrowding and identify associated factors at HARME Medical Emergency Center, located in Hiwot Fana Comprehensive Specialized Hospital, Harar, Ethiopia.

Methods: A cross-sectional study was conducted at the HARME Medical Emergency Center, Hiwot Fana Comprehensive Specialized Hospital, involving a total of 899 patients during 120 sampling intervals. The area under the receiver operating characteristic curves (AUC) was calculated to evaluate the agreement between objective and subjective assessments of ED overcrowding. A multivariable logistic regression analysis was employed to identify factors associated with ED overcrowding and statistically significant association was declared using 95 % confidence level and a p-value < 0.05.

Results: The interrater agreement showed a strong correlation with a Cohen's kappa (κ) of 0.80. The National Emergency Department Overcrowding Study Score demonstrated a strong association with subjective assessments from residents and case team nurses, with an AUC of 0.81 and 0.79, respectively. According to residents' perceptions, ED were considered overcrowded 65.8 % of the time. Factors significantly associated with ED overcrowding included waiting time for triage (AOR: 2.24; 95 % CI: 1.54–3.27), working time (AOR: 2.23; 95 % CI: 1.52–3.26), length of stay (AOR: 2.40; 95 % CI: 1.27–4.54), saturation level (AOR: 2.35; 95 % CI: 1.31–4.20), chronic illness (AOR: 2.19; 95 % CI: 1.37–3.53), and abnormal pulse rate (AOR: 1.52; 95 % CI: 1.06–2.16).

Conclusion: The study revealed that ED were overcrowded approximately two-thirds of the time.

Introduction

The Emergency Department (ED) plays a vital role in the treatment of critically ill and acute ambulatory patients. The role of ED is evolving due to the dynamic nature of healthcare system in response to economic, clinical, and political pressures [1,2]. There are no universally accepted criteria to assess ED overcrowding. However, many emergency care providers define ED overcrowding as "a circumstance in which the demand for emergency services exceeds the capacity to deliver appropriate care within a reasonable time" [3–7]. It is one of the most extensive and difficult problems that the world's healthcare systems are currently facing. The rising demand for hospitals and EDs is also a major issue for many tertiary emergency centers [8].

The current crisis in emergency care systems is characterized by worsening of ED overcrowding [9]. Emergency department overcrowding is a global problem, particularly in urban academic medical centers [4]. Emergency department overcrowding was 62 %, 57.7 %, and 86.67 % in the United States of America (USA), Argentina, and

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India, respectively [3,10,11].

There are various proposed measuring tools for ED overcrowding [12]. Hospitals can establish systems to handle high ED patient crowding routinely and avoid poor patient outcomes by using measuring tools or metrics [13]. Some of these tools include the National Emergency Department Overcrowding Study Score (NEDOCS) [4], the international crowding measure in emergency departments [14], the emergency department work index [7,15] triage categories and numerical values about ED capacity and the real-time emergency analysis of demand indicators [4,16], and subjective assessment of ED overcrowding nurse and emergency physician can be assessed [6,11].

The NEDOCS is considered to be a simple measure of ED overcrowding across multiple institutions [4]. A study conducted in Salt Lake City at a Level I trauma center showed that the NEDOCS had the highest sensitivity (0.81), specificity (0.87), and positive predictive value (0.62) compared with Emergency department work index (EDWIN) and Real-time emergency analysis of demand Indicators scores (READI) [17].

The ED overcrowding has been associated with multiple adverse outcomes including decreased quality of care and increased mortality. Overcrowding is also associated with critically ill patients waiting for too long for care [18]. A study conducted in the USA reported that only 67 % of acutely ill patients were observed within the recommended times [19]. Studies conducted in South Africa have shown inferior care rendered during times of overcrowding by delaying the provision of analgesia for adults with abdominal pain and the painful presentation of patients [3,20,21]. It threatens the quality of care by delaying the time for diagnosis and treatment of patients with time-sensitive diseases such as acute stroke [22]. It is also associated with the forced discharge of patients to a home to which they would normally have been admitted to avoid contributing to overcrowding of the ED and hospital [23]. To date, ED overcrowding has not been evaluated in the regional state of Harari in eastern Ethiopia. This study aimed to validate NEDOCS, level of ED overcrowding and its associated factors at the HARME Medical Emergency Center, Hiwot Fana Comprehensive Specialized Hospital (HFCSH), Harar, Ethiopia from November to 01–30, 2022.

Methods

Study design, setting and period

A cross-sectional study was conducted at the ED of HARME Emergency Medical Center, located within HFCSH in Harari Regional State, Eastern Ethiopia. Harari Region is situated approximately 526 kms east of Addis Ababa and has an estimated population of 270,344. HFCSH serves as a teaching and referral hospital for the eastern part of Ethiopia, including Eastern Oromia, Dire Dawa City Administration, the Somali Regional State, and the Harari Regional State. It has a catchment population of 5.8 million and is equipped with 238 inpatient beds eds [24]. The ED at HFCSH receives an average of 950 patient visits per month, as reported in the 2022 Annual HFCSH performance report. The ED itself has 30 beds available for patient care. The study was conducted from November 1st to November 30th, 2022.

Study participants, sample size and sampling procedure

This study included all patients who visited the ED, as well as senior emergency medicine residents and nurse case team heads. Patients who did not go through the emergency triage system and those with incomplete chart information (age, sex, residency, and triage sheet) were excluded. The sample size for the study was determined based on the outcome variable and factors that were found to be significantly associated with ED overcrowding. Hour-to-hour variation was assessed using four specific time points (12:00 a.m., 6:00 a.m., 12:00 p.m., and 6:00 p.m.) for subjective assessment by the in-charge case team head and senior emergency medicine resident, while simultaneously calculating the NEDOCS score [25].

To capture variations related to weekdays versus weekends and working and duty time variations in ED overcrowding, a one-month duration was chosen [26]. This resulted in a total of 120 sampling time points. All patients who met the inclusion criteria during the study period were included in the assessment of factors associated with the outcome variable.

Data collection methods

A data collection tool was developed from prior studies [3,18,20,27–34], and its content validity (content validity index of 0.81) was assessed and assured by six senior experts of emergency physician practicing in Ethiopia. The questionnaire had three parts. The first section included the socio-demographic characteristics of the patient (age, sex, residency, chief complaint of the patient, time of admission, comorbidities, and triage severity index). The second and third sections included subjective assessment with Likert scale and objective assessments with NEDOCS, respectively.

Data was collected by five well-trained Emergency nurse practitioners.

Subjective overcrowding

A composite variable was created as the average of both nurses' and senior emergency medicine residents' scores for feeling overcrowded [6]. Senior Emergency Medicine residents and ED case team nurses were approached independently to assess the level of ED overcrowding. They asked, 'How busy is the ED right now, considering the total number of patients, workload, and doctors and nurses?' They answered from a given list of multiple answers that ranged from not crowded or busy at all to dangerously overcrowded, and each was expected to choose one response [26].

Objective overcrowding

The National emergency department overcrowding scale scores were calculated as follows:

NEDOCS score = 85.8(C/A) + 600(F/B) + 13.4(D) + 0.93(E) + 5.64 (G) – 20) [34].

A - ED total number of beds

B – Hospital total number of beds

C – ED total number of patients presented

D – ED total number of patients who is on a mechanical ventilator.

E - Length of stay: [35] patients who waited for admission to the hospital for the longest time in the ED

F – Total number of the patients waiting for admission to ED

G - The time [35] passing after the admitted last patient

The scores were as follows: not busy ED (0–20), busy ED (21–60), very busy ED (61–100), overcrowded ED (101–140), dangerous ED (141–180), and disasters (> 181) [6].

Data were collected by five well-trained emergency nurses. subjective and objective overcrowding measurement scores were collected at 12:00 a.m., 6:00 a.m., 12:00 p.m. and 6:00 p.m. There was only one senior emergency medicine resident and one shift case team head for each data point. The senior emergency medicine resident and ED case team nurse were independently approached to answer the subjective feeling of overcrowding based on the Likert scale, following which the NEDOCS forms were filled, and the NEDOCS score was calculated by the data collectors simultaneously. The remaining questionnaires were filled out prospectively from patient charts.

Operational definition

Validated NEDOCS is validated when the score is comparatively assessed for ED overcrowding using a subjective assessment of the clinical care provider (Weiss et al., 2006).

Emergency overcrowding ED overcrowding was categorized as overcrowded (NEDOCS ≥100 or Likert scale ≥ 4) or not overcrowded

(NEDOCS <100 or Likert scale < 4) [7,26].

Exit boarding occurs when patients in the ED requiring inpatient care are unable to gain access to appropriate hospital beds within eight hour of admission decision [32].

Data quality control

To ensure the quality of the data, a pretest was done for three days at the emergency unit of Jugal General Hospital to determine the validity and reliability of the data collection format. Prior to commencing the data collection procedure, the agreement of the questionnaires was ensured through training provided to the data collectors. Supervision and check-up were carried out by the trained supervisor to ensure the completeness and consistency of the data. During the data management, storage, and analysis processes, every component of the collected data was checked for completeness and consistency.

Data processing and analysis

Data were coded, entered into EpiData 3.1, and exported to SPSS version 25.0 for analysis. The data were cleaned and checked for completeness with simple frequencies and cross tabulation. ED overcrowding was categorized as overcrowded (NEDOCS ≥100 or Likert scale ≥ 4) and not overcrowded (NEDOCS <100 or Likert scale < 4).

Categorical variables were described as frequencies and percentages. Continuous variables were screened for normality using the Kolmogrov-Smirnov test and presented as means and standard deviations (SDs) in the case of normal distribution or medians and interquartile ranges (IQRs) in the case of non-normal distribution. Comparisons of continuous data were performed using two-sample Wilcoxon rank-sum (Mann-Whitney) test for non-normal distribution variables. The interrater agreement on the perception of ED overcrowding was assessed with a Cohen's kappa (κ). The agreement of the objective assessment of NEDOCS score with subjective assessment of senior emergency medicine residents and the case team nurse for ED overcrowding was assessed with the area under the receiver operating characteristic curves (AUC) [26]. Test characteristics (sensitivity, specificity, positive and negative predictive values) were calculated for a NEDOCS score.

Bivariable and multivariable logistic regression analyses were done to identify the association between independent variables and ED overcrowding. Variables with $p \leq 0.25$ in the bivariable analysis were included in the final model of multivariable analysis to control all confounding variables. The goodness of fit of the model was tested by the Hosmer-Lemeshow statistic test. The model was considered a good fit since it was found to be insignificant for the Hosmer-Lemeshow statistic ($p = 0.914$). A multicollinearity test was carried out to see the correlation between independent variables using correlation coefficient, and no variables were observed with value of > 0.8, indicating the non-existence of multicollinearity among the variables in this study. The crude odds ratio (COR) and adjusted odds ratio (AOR) were calculated with the 95 % confidence interval to measure the strength of the association between the outcome and independent variable and the variable with a P-value less than 0.05 in the multivariable analysis was considered significantly associated with ED overcrowding.

Ethical consideration

This study received ethical approval from the Institutional Health Research Ethics Review Committee of Haramaya University College of Health and Medical Sciences, ensuring compliance with ethical guidelines. Participants' confidentiality was strictly maintained by removing any identifying information from the data. Prior to data collection, informed, voluntary, written, and signed consent was obtained from the head of the institution and all participants involved in the study. It is worth noting that the principal investigator did not participate as a data collector in this study to avoid bias. Given the context of the COVID-19 pandemic, all necessary precautions and standard safety measures were followed during the data collection process to minimize the risk of transmission. These measures were implemented to ensure the safety and well-being of both participants and data collectors.

Result

Base line characteristics

One hundred twenty sampling times were used for ED overcrowding assessment and 899 patients were included in this study. A total of 13 patients were excluded from the study due to 2 patients were directly seen at front track by a physician without triaging and 11 patients didn't have a triage sheet due to interruption of triage sheet supply. The median (IQR) age of patients the study participants was 30 (20) years, and the largest age category was15–65 years (748, 83.2 %). Most of the participants were male (552, 61.4 %). More than half of the participants were from urban area (493, 54.8 %). Majority of the patients were self-referral (631, 70.2 %). One third (298, 33.1 %) of the patient were having insurance for health care. Almost half (449, 49.9 %) of the patients were using taxi for transportation to the hospital (Table 1).

The common presentation of chief complaints in this study was sustaining from trauma (340, 37.8 %), gastrointestinal (GI) symptoms (195, 21.7 %), and neurologic symptoms (113, 12.6 %). Most (805, 89.6 %) of the patients were presented with a chief complaint duration of less than one week, (417, 46.4 %) ≤ 24 h, and (388, 43.2 %) 1–7 days. Trauma related diagnosis (340, 37.8 %) and non-surgical GI emergencies (101, 11.2 %) were the commonest admission diagnosis (Table 2).

Most of the patients were seen during working hour (575, 64.0 %) and weekdays (637, 70.9 %). Mean waiting time for triaging was 5.55 ± 3.94 min. Majority (632, 70.3 %) of the patients' emergency severity index were yellow/green. Prolonged ER length of stay more than 24 h were 135 (15 %) patients. The median (IQR) ED boarding time for admission was 9 (13) h. Majority of patients (718, 79.9 %) were discharged from emergency whereas 20 (2.2 %) of the patents were admitted to critical care unit (Table 2).

Only 198 (22.0 %) of patients were having chronic illness. Peptic ulcer disease (77, 38.9 %), cardiovascular disorder (31, 15.6 %), and diabetes mellitus (30, 15.15 %) were the common comorbidity in this study group.

Among patients who stayed for more than 24 h due to lack of bed was the main reason (79.3 %) followed by lack of money for admission (14.1 %) (Fig. 1).

Table 1
Socio-demographic characteristics of patients attending HARME ED, HFCSH, Harar, Eastern Ethiopia from November 01–30, 2022 ($n = 899$).

Variable	Category	Frequency (%)
Sex	Male	552 (61.4)
	Female	347 (38.6)
Age	<15	95 (10.6)
	15–65	748 (83.2)
	>65	56 (6.2)
Residency	Urban	493 (54.8)
	Rural	406 (45.2)
Source of Referral	Private facility	43 (4.8)
	Hospital	72 (8.0)
	Health Center	153 (17.0)
	Self	631 (70.2)
Insurance	No	601 (66.9)
	Yes	298 (33.1)
Mode of arrival	Walking	185 (20.6)
	Taxi	449 (49.9)
	Private car	135 (15.0)
	Ambulance	130 (14.5)

Table 2
Clinical characterstics of patients attending HARME ED, HFCSH, Harar, Eastern Ethiopia from November 01–30, 2022 ($n = 899$).

Variable	Category	Frequency (%)
Chief complaints	Chest pain	23 (2.6)
	Body swelling	24 (2.7)
	Urinary complaints	27 (3.0)
	Neurologic symptoms	113 (12.6)
	Cough	47 (5.2)
	Fever	18 (2.0)
	GI Symptoms	195 (21.7)
	MSK Symptoms	52 (5.8)
	Shortness of breath	57 (6.3)
	Trauma	340 (37.8)
	Vaginal bleeding and follow up	3 (0.3)
Duration of chief complaints	≤ 24 h	417 (46.4)
	≤ 1 week	388 (43.2)
	≤ 4 weeks	75 (8.3)
	> 4 weeks	19 (2.1)
Admission diagnosis	Acute abdomen	60 (6.7)
	Cardiovascular emergencies	66 (7.3)
	Pulmonary emergencies	92 (10.2)
	Renal emergencies	31 (3.4)
	Trauma	338 (37.6)
	Endocrine emergencies	28 (3.1)
	GI emergencies	101 (11.2)
	Hematologic emergencies	32 (3.6)
	Infectious emergencies	92 (10.2)
	Oncologic emergencies	10 (1.1)
	Neurologic emergencies	34 (3.8)
	Poisoning	11 (1.2)
	Psychiatric emergencies	4 (0.4)
Chronic illness	No	701 (78)
	Yes	198 (22.0)
Time of admission	Duty time	324 (36.0)
	Working hour	575 (64.0)
Admission day	Week day	637 (70.9)
	Weekend	262 (29.1)
Emergency severity Index	Yellow/Green	632 (70.3)
	Orange	142 (15.8)
	Red	125 (13.9)
Waiting time for triage	≤ 5 Min	528 (58.7)
	>5 Min	371 (41.3)
ER disposition	Discharged from ER	718 (79.9)
	Left without being seen	45 (5.0)
	Died at ER	7 (0.8)
	Surgical ward	37 (4.1)
	Medical ward	72 (8.0)
	ICU	20 (2.2)
ER length of stay	≤ 24 h	764 (85.0)
	> 24 h	135 (15.0)
ED Boarding, median (IQR), ($n = 270$)	9 (5–18) hours	
Saturation	≥90 %	734 (81.6)
	<90 %	165 (18.4)
Respiratory Rate	Normal	514 (57.2)
	Abnormal	385 (42.8)
Pulse Rate	Normal	521 (58.0)
	Abnormal	378 (42.0)

ED: Emergency department; ER: Emergency room; MSK: Musculoskeletal; GI: Gastrointestinal; ICU: Intensive care unit; IQR: Interquartile range.

Validation of NEDOCS

The interrater agreement of senior emergency medicine residents and case team nurses on perception of ED overcrowding was strongly correlated with a Cohen's kappa (κ) of 0.80 (P <0.001). The objective assessment of the NEDOCS score for ED overcrowding was strongly associated with the subjective assessment by senior emergency medicine residents and case team nurses (AUC = 0.81 (95 % CI 0.72–0.91), $P <$ 0.001) and case team nurses (AUC = 0.79 (95 % CI 0.69–0.88), $P <$ 0.001), respectively (Fig. 2).

The sensitivity and specificity of the NEDOCS ED overcrowding score were 96.15 % and 66.67 %, respectively. The positive and negative predictive values of NEDOCS for ED overcrowding were 84.27 % and 90.32 %, respectively.

Emergency department overcrowding

The median overcrowding score was 198 (IQR =90) for NEDOCS, 4.01 (IQR =2) for emergency physician residents, and 3.89 (IQR =2) for nurses. Emergency department was considered overcrowded in 78 (65.0 %) of the times according to nurses and 79(65.8 %) of the times according to emergency physician residents' response. According to the NEDOCS, the overall proportion of ED overcrowding was 89 (74.2 %) times.

Factors associated with ED overcrowding

Variables with a p-value less than 0.25 in the bivariable analysis, were included in the multivariable logistic regression. In the final model, the waiting time for triage, working time, length of stay, saturation, chronic illness, and pulse rate were significantly associated with ED overcrowding (Table 3).

The odds of ED overcrowding were increased by more than two-fold (AOR:2.24; 95 % CI:1.54–3.27) among patients triaged for more than five minutes than those triaged within five minutes. The odds of ED overcrowding increased by 2.23 (AOR:2.23; 95 % CI:1.52–3.26) times during duty hours compared to working hours. The odds of ED overcrowding among patients who stayed for more than 24 h were 2.40 (AOR:2.40; 95 % CI:1.27–4.54) times higher than in patients who stayed less than or equal to 24 h. A saturation of less than 90 % increase the odds of ED overcrowding by 2.35 (AOR:2.35; 95 % CI:1.31–4.20) times compared with patients who had saturation of ≥90 %. Chronic illness increased the odds of ED overcrowding by more than two-fold (AOR:2.19; 95 % CI:1.37–3.53) compared to patients who did not. The odds of ED overcrowding were increased by 52 % (AOR:1.52; 95 % CI:1.06–2.16) among patients with an abnormal pulse rate compared to those with a normal (60–100 beats/minute) pulse rate (Table 3).

There was significant difference in the median (IQR) ED boarding time during overcrowded and not overcrowded, 5 h (IQR, 2) and11 h (IQR,16) (Mann-Whitney U test p value < 0.001), respectively.

Discussion

This study showed that interrater agreement on the subjective perception of ED overcrowding by senior emergency medicine residents and nurse case team heads was strong. The agreement between subjective perception of ED overcrowding (senior emergency medicine residents and case team nurses) and NEDOCS assessment was strongly associated with AUC value of 0.81 and 0.79, respectively. Emergency department considered to be overcrowded in 65.0 % of the time. Emergency department overcrowding was significantly associated with waiting time for triage, working time, length of stay, chronic illness, and vital signs (pulse rate and saturation).

This study demonstrated that the objective assessment of NEDOCS score for ED overcrowding was strongly associated with subjective assessment of senior emergency medicine residents and case team nurses. The interrater agreement on perception of ED overcrowding was strongly correlated. Similarly, the study done in East England [29], Buenos Aires, Argentina [10], Western Sussex Hospitals NHS Foundation Trust, UK [25], level 3 trauma center of the University of New Mexico, Netherland [26], Southern, USA [30], Salt Lake City hospitals, USA [17], and Vanderbilt University Medical Center, USA [36,37] showed the objective assessment of NEDOCS is highly correlated with the subjective perception of ED overcrowding. This strong correlation of NEDOCS tool and subjective perception of ED overcrowding will help in accurate measurement of ED overcrowding by easily calculation of NEDOCS among all health care professionals including junior staffs. In

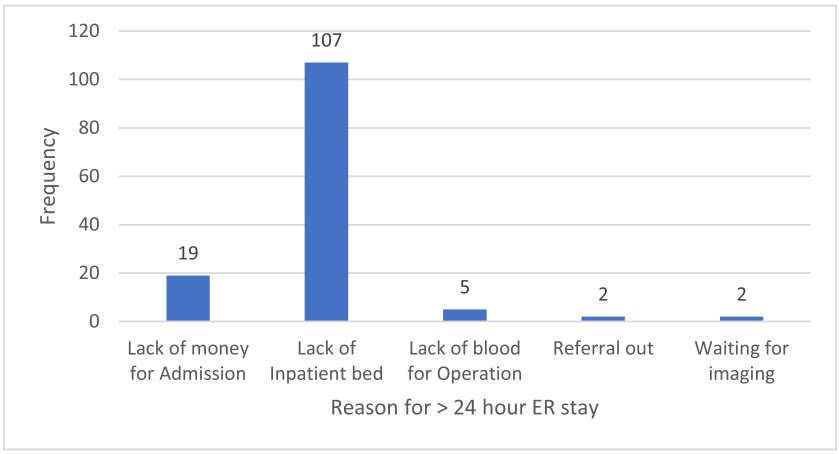

Fig. 1. Reasons for patient stay more than 24 h among patients attending HARME ED, HFCSH, Harar, Eastern Ethiopia from November 01–30, 2022 ($n = 135$).

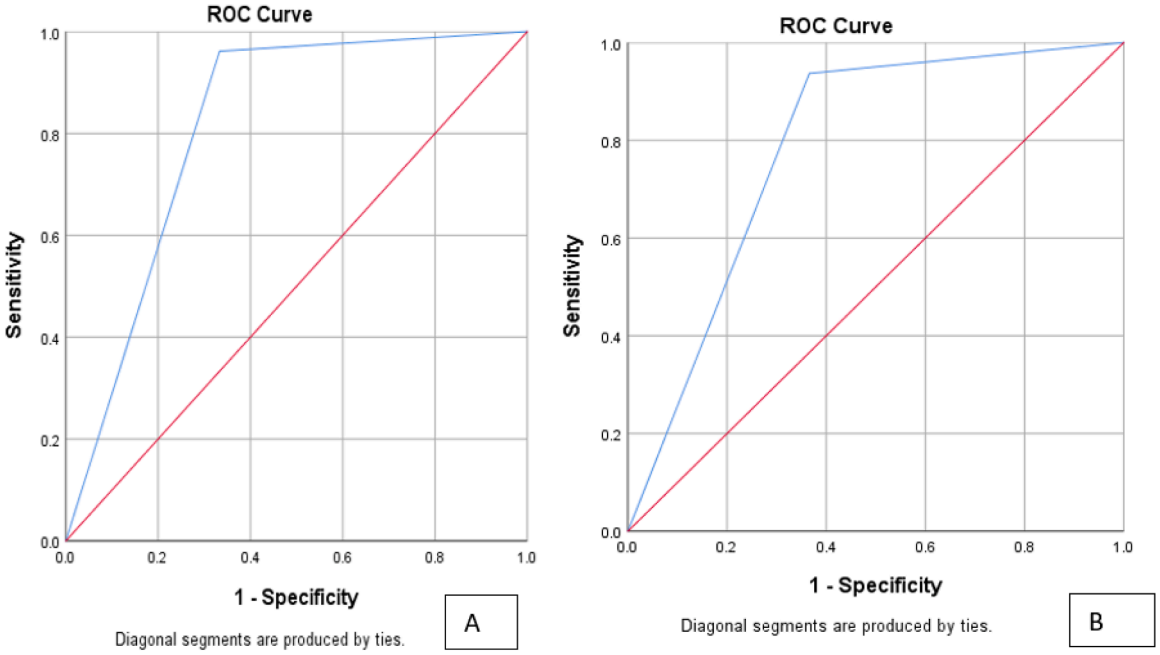

Fig. 2. Receiver operating characteristic curves of NEDOCS score for ED overcrowding plotted against A) Senior emergency medicine residents', and B) case team nurses' perception of ED overcrowding at HARME ED, HFCSH, Harar, Eastern Ethiopia from November 01–30, 2022.

contrast to this study, a study done in university hospital of Turkey revealed there was a weak correlation between ED overcrowding perception and NEDOCS score (Spearman correlation coefficient: 0.214) [34]. This difference could be explained difference in study setting and population. Since the longest boarding time of patients waiting for admission parameter was longer than 24 h, which resulted in exaggeration and over estimation of NEDOCS score for ED overcrowding.

In this study, the sensitivity and specificity of NEDOCS for ED overcrowding were 96.15 % and 66.67 %, respectively. A study done by Hargreaves *et al.*, (2020) showed the sensitivity and specificity of NEDOCS was 75.9 % and 72.1 %, respectively [25]. Similarly, a study done Jones by *et al.*, (2006) also revealed that NEDOCS had high sensitivity and specificity with AUC value of 0.92, 81 % and 87 %, respectively (0.62) [17]. Therefore, it is reasonable to use the NEDOCS tool to quantify the subjective perception of ED overcrowding in our setting, where many junior residents and medical interns rotate for attachment to the ED.

In our study, Emergency was considered overcrowded 65.0 % of the time. This study's findings are similar to those from studies conducted at the University of New Mexico, Southern USA (62 %) [30], Saudi Arabia (62.7 %) [38] and Canada (62 %) [39]. The study also conducted by Sharma *et al.*, (2021) at tertiary care centers in Northern India on the perceptions of ED overcrowding by ED physicians and nurses was also very high (83.34 % and 86.67 %, respectively [11]. By contrast, Swedish EDs (18.2 %)[16], UK ED were overcrowded by 18.5 % [25]. The reason for this discrepancy could be explained by differences in hospital level and characteristics, capacity of inpatient beds for admission of patients from the ED, and the proportion of patient flow and availability of healthcare professionals. Since many patients visit tertiary centers directly for better care, ED overcrowding is a challenge for referral hospitals [2].

The cutoff time for prolonged ED length of stay (LOS) varies from country to country. Prolonged ED LOS is considered in Ethiopia > 24-hour [40], whereas in Australian government (4 h) [41], in UK (4 h) [42,43], in New Zealand (6-hours) [44], in Korea (24 h) [43] and in China (72 h) [45]. In this study, the odds of ED overcrowding were increased 2.4 times among patients who stayed for more than 24 h in the ED than among those who stayed for less than 24 h (AOR:2.40, 95 %

Table 3
Factors associated with ED overcrowding at HARME ED, HFCSH, Harar, Eastern Ethiopia from November 01–30, 2022 ($n = 899$).

Variables		ED overcrowding		COR (95 % CI)	AOR (95 % CI)
		Yesn (%)	Non (%)		
Waiting time for triage	≤5 Min	394 (55.1 %)	134 (72.8 %)	1	1
	>5 Min	321 (44.9 %)	50 (27.2 %)	2.18 (1.53–3.12) **	2.24 (1.54–3.27) **
Working time	Duty	279 (39.0 %)	45 (24.5 %)	1.98 (1.37–2.86) **	2.23 (1.52–3.26) **
	Working	436 (61.0 %)	139 (75.5 %)	1	1
Length of stay	≤24 h	592 (82.8 %)	172 (93.5 %)	1	1
	>24 h	123 (17.2 %)	12 (6.5 %)	2.98 (1.61–5.52) *	2.40 (1.27–4.54) *
Saturation	≥90 %	565 (79.0 %)	169 (91.8 %)	1	1
	<90 %	150 (21.0 %)	15 (8.2 %)	2.99 (1.71–5.23) **	2.35 (1.31–4.20) *
Chronic illness	Yes	172 (24.1 %)	26 (14.1 %)	1.93 (1.23–3.02)	2.19 (1.37–3.53) *
	No	543 (75.9 %)	158 (85.9 %)	1	1
Respiratory rate	Normal	404 (56.5 %)	117 (63.6 %)	1	1
	Abnormal	311 (43.5 %)	67 (36.4 %)	1.34 (0.96–1.88)	0.95 (0.66–1.36)
Pulse rate	Normal	393 (55.0 %)	121 (65.8 %)	1	1
	Abnormal	322 (45.0 %)	63 (34.2 %)	1.57 (1.12–2.21) *	1.52 (1.06–2.16) *

COR, crude odds ratio; AOR: Adjusted odds ratio; CI: Confidence interval. $^{**}P < 0.001$, $^{*}P < 0.05$.

CI:1.27–4.54). The findings of this study is also in line with studies conducted by Bond et al. (2007) in Canada [39], by Hsu et al. (2014) and Hwang et al. (2011) in China [33,45]. Patients with prolonged ED LOS due to different factors, mainly delays in obtaining inpatient beds, result in ED overcrowding [46,47].

In this study, there was significant difference in the median (IQR) ED patient boarding time during overcrowded and not overcrowded. This is in congruent with previous reports by Schull et al. (2002)[12], Pines et al. (2011) [2], Affleck et al. (2013) [48], Mason et al. (2017) [32] and Forero et al. (2011) [49]. Although there is no single factor that could explain why ED crowding occurs, ED boarding was found to be the single most common factor [50,51]. As ED overcrowding is strongly associated with ED patient boarding due to a shortage of inpatient beds, it reflects hospital overcrowding [52]. Similarly, this study also showed that the main reason for delayed inpatient admission (79.3 %) was lack of inpatient beds. This could be explained by our hospital characteristics of physically separated ED centers and main hospitals and the poor liaison system of patient admission that resulted from direct admission from the outpatient department without consideration of critically ill patients from the ED.

In the current study, the odds of ED overcrowding increased by 2.24 times among patients triaged more than five minutes than among patients triaged within five minutes (AOR:2.24, 95 % CI:1.54–3.27). Consequently, ED overcrowding can result in prolonged patient waiting and triaging times for triage officers, which could create a vicious cycle. According to a study by Fields (2003) and van der Linden et al., (2016), patients who arrived during overcrowding more often had delayed triaging times than those who did not ($P < 0.001$) [50,53].

This study revealed that duty hours were 2.23 times more overcrowded than working hours (AOR:2.23, 95 % CI:1.52–3.26). In contrast to this finding, a study conducted in the USA showed that ED overcrowding scores tended to fall between midnight and 6 AM because of decreasing patient volume and rising rapidly between 8 AM and noon [54]. This discrepancy could be explained by the difference in the proportion of duty times of healthcare professionals and patient flow. More than one-third (36.4 %) of the patients visited during duty hours despite a smaller number of duty physicians, difficulty in disposition of patients, and work-up of patients for diagnosis. This could also result from the diversion of cold patients to the ED because of referral clinic closures during duty.

The present study showed that the odds of ED overcrowding increased by more than two-fold in patients with chronic illnesses (AOR:2.19, 95 % Cl:1.37–3.53). Similarly, a study conducted in China also showed that ED overcrowding was significantly associated with comorbidities, which resulted from difficulties in disposition from the ED [28]. Emergency department also perceived a grant for worsening of chronic illness facility visits, which was associated with frequent use of ED services, resulting in crowding [55]. ED overuse is growing and problematic for departments, resulting in overcrowding, long waits, overly stressed healthcare providers, and compromised emergency care for patients with true emergencies [56].

Patient vital signs are vital for determining patient admission, prognosis and outcomes [27]. In this study patients having abnormal vital signs in saturation (< 90 %) and abnormal pulse rate increase the odds of ED overcrowding by 2.35 (AOR:2.35; 95 % CI:1.31–4.20) times and 52 % (AOR:1.52; 95 % CI:1.06–2.16), respectively. In parallel to this study, a study conducted in Los Angeles, USA, also showed vital signs with at least twice the odds of admission with an abnormal pulse rate and saturation [57]. This results in a high threshold for the admission of patients to the ED by healthcare professionals, which is associated with ED overcrowding.

This study had some limitations. First, the study had a cross-sectional design in which we could not avoid the temporality of the factors associated with ED overcrowding. Second, this study was conducted at a single institution, and it is difficult to generalize the results to national ED overcrowding. Third, this study was conducted every 6 h for one month. Therefore, the hourly and seasonal changes within the same institution were not assessed. Fourth, in this study, ED boarding was high, which could lead to an overestimation of the NEDOCS, which could not be ruled out. Therefore, the findings of this study should be interpreted in consideration of the aforementioned limitations.

Conclusion

Objective assessment of ED overcrowding using the NEDOCS tool was strongly associated with subjective perceptions of ED overcrowding. In the current study, the ED was overcrowded two thirds of the time. Emergency department overcrowding was strongly associated with abnormal vital signs (saturation level and pulse rate), ED length of stay, target triage timing, and working time. Four of the five patients were boarded in the ED because of a lack of inpatient beds for admission. Hospital administrators should work to improve the ED.

Dissemination of result

The result of this study presented to department of Emergency medicine, HFCSH. It was also submitted to the college of health and

medical sciences, Haramaya University, and the Harari regional health bureau. It will be presented to Ethiopian society of emergency and critical care professionals.

Contribution of authors

Authors contributed as follow to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: MG contributed 40 %; IM & FA contributed 15 %; and ND, LB and BH contributed 10 % each. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of Competing Interest

The authors declared no conflicts of interest.

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