

# NEDOCS: is it really useful for detecting emergency department overcrowding today?

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## Abstract

The Emergency Department (ED) overcrowding is an ongoing problem all over the world. The scoring systems are available for the detection of this problem. This study aims to test the applicability of the National Emergency Department Overcrowding Study (NEDOCS) scoring system, one of the scoring systems that evaluate the ED overcrowding.

In this prospective observational study, the survey was applied on on-duty doctors, nurses, paramedics, intern doctors, and ward persons working in a University Adult Emergency Department and agreed to participate in the study, between certain hours during the day and the NEDOCS score was calculated simultaneously. The demographic characteristics of the on-duty staff, overcrowding of ED, and the number of the on-duty staff members were recorded in the questionnaires.

During the study, 153 measurements were performed, and 3221 questionnaires were filled. The NEDOCS mean score was determined as 101.59 and the most reached result was “extremely busy but not overcrowded” (32%). The ED was rated mostly as “busy” (33.7%) by the on-duty staff. A significant difference was found between ED overcrowding and NEDOCS score. There is a significant difference between ED overcrowding and on-duty emergency nurse and intern doctor count.

The NEDOCS score is not suitable for evaluating ED overcrowding. Accurate determination of the ED overcrowding is very important to avoid the negative consequences of the ED overcrowding. Increasing emergency nurse and intern doctor count will decrease ED overcrowding. Also, there is an urgent need to constitute local hospitals and also public health policies to satisfy the increasingly ED's presentations.

**Abbreviations:** ED = emergency department, NEDOCS = National Emergency Department Overcrowding Study.

**Keywords:** emergency department, national emergency department overcrowding study, overcrowding

## 1. Introduction

All over the world, the emergency department (ED) overcrowding is now becoming a public health problem.<sup>[1]</sup> ED overcrowding has differed from department to department, and there is not any universally accepted definition, gold standard test, and cut-off value covering all kinds of departments.<sup>[2–5]</sup> There are many reasons for ED overcrowding. Some of the

reasons for ED overcrowding are EDs are open 24/7, and the examinations, workups, and imaging can be performed without an appointment.<sup>[6,7]</sup> Additionally, most of the ED patients think that their complaint is urgent, and they could not get an appointment from their primary care physicians.<sup>[8,9]</sup> Also, hospital-related factors such as staff shortages, diagnostic delays, and lack of inpatient beds could cause overcrowding.<sup>[10]</sup> Because of these and similar reasons, EDs have difficulty in dealing with admissions that exceed their available capacity.

Researchers try to implement different methods in ED settings to solve the ED overcrowding and to decrease the waste times in the ED. One of them is the “Leaning management model,” which originates from Toyota production systems. It is shown that the leaning model successfully decreases the waiting times in ED.<sup>[11,12]</sup> Also, one of them is “4-hour rule” was described in 2004 in the United Kingdom, but it did not solve ED overcrowding and access block as expected because four hours are not enough for some of the ED patients.<sup>[13,14]</sup> Every ED is trying to find their suitable solution for ED overcrowding.

ED overcrowding leads to many unwanted results such as increased inpatient mortality and higher rates of leaving ED without been seen.<sup>[15]</sup> Also, as the ED overcrowding increases, the verbal and physical violence events increase, the waiting time of patients increases, the employee satisfaction decreases, and the healthcare quality and the patient satisfaction decrease.<sup>[16–20]</sup>

Determination of ED overcrowding level is crucial in avoiding unwanted results. If the overcrowding level measured currently, the overcrowding plans can introduce. Various scoring systems have been developed to detect ED overcrowding. Some of these

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include real-time emergency analysis of demand indicators, Emergency Department Work Index, National emergency department overcrowding study (NEDOCS), and emergency department crowding scale scoring systems. NEDOCS has achieved good results among these scoring systems.<sup>[2,21]</sup> Again in a study comparing emergency department work index and NEDOCS, NEDOCS achieved more successful results.<sup>[22]</sup> The NEDOCS score is a scoring system defined by Weiss et al, in 2004 and assessing the ED overcrowding objectively.<sup>[19]</sup>

This study aimed to test the usability of the NEDOCS score in assessing the overcrowding in a University Hospital Adult Emergency Department.

## 2. Methods

### 2.1. Study design and population

This prospective observational study was conducted between 16 August 2015 and 17 September 2015 after the local ethics committee approval was received (GO15/497-10).

The annual number of patient visits to the university hospital, where the study was conducted, was approximately 650,000, and the ED visits were about 30,000. It is the most preferred academic tertiary center to which oncological and geriatric patients mostly present besides all emergency patients. Our ED has 130 staff, including doctors, nurses, paramedics (working as triage personnel in the ED), intern doctors, and ward persons. A total of 120 of 130 ED staff gave informed consent and participated in the study.

### 2.2. Study protocol

The survey study was applied to the on-duty ED staff in certain hours (09:00–13:00-17:00-21:00-01:00-05:00) during the day. The study hours were determined not to coincide with the shift change hours (because of all staff’s bedside shift change visits) and to represent the day and night duties equally. The participants who wanted to fill in the questionnaire were included in the study based on voluntary participation. Also, informed consent was obtained. While one researcher calculates and writes the NEDOCS score to NEDOCS forms, one different researcher collects the ED overcrowding perception survey simultaneously. The participants were asked to evaluate the current ED overcrowding without knowing the answers of the others, and were asked to score the ED overcrowding perception from 1 to 6 (1: not busy; 2: busy; 3: extremely busy but not overcrowded; 4: overcrowded; 5: severely overcrowded; 6: dangerously overcrowded). Missing surveys were excluded from the study. Total number of beds in ED (A), total number of beds in the hospital (B), total number of the patients in ED (C), the number of the patients treated with mechanical ventilator in ED (D), the length of stay (hour) of the patients who waited for the admission to hospital for the longest time in ED (E), the number of the patients waiting for the admission in ED (F), and the time (hour) passing after the admitted last patient (G) included in the NEDOCS forms were filled, and NEDOCS score was calculated by the researchers simultaneously. The NEDOCS score was calculated according to the original formula (NEDOCS score =  $85.8(C/A) + 600(F/B) + 13.4(D) + 0.93(E) + 5.64(G) - 20$ ). The survey could not be performed at the times when no patient was waiting in the triage to be examined in ED. In the original formula, “the time (hour) passing after the admitted last patient

(G)” is a parameter for calculating the NEDOCS score, and the empty waiting room causes a higher NEDOCS score. Because of the empty waiting room and to avoid the calculation bias 05:00 questionnaires were excluded from the study.

### 2.3. Statistical analysis

The statistical analysis was performed using the SPSS for Windows 21.0 packaged software. The categorical variables were demonstrated with numbers and percentages. The numerical variables were demonstrated with median (minimum-maximum). The relationship between categorical variables was assessed with Pearson’s Chi-Square and Eta correlation coefficient. The correlations of the groups assessed with Spearman correlation coefficient.

## 3. Results

During the study, a totally 3191 patients presented to the ED. A total of 2536 (79.5%) of these patients had outpatient care and were discharged from ED, 496 (15.5%) had inpatient treatment, and 159 (5.0%) left without being seen.

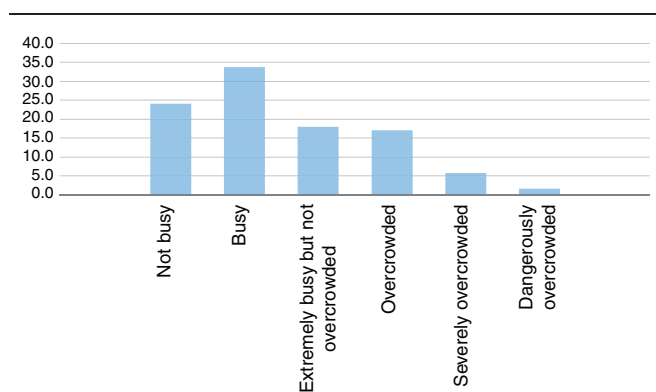
Totally 3221 questionnaires were filled, and 153 NEDOCS score measurements were performed in the 5-week period. A total of 120 of 130 ED staff gave informed consent and participated in the study. The median age of the participants was 25 (20–44) years, and 51% of them were women. The median NEDOCS score was 99.96 (15.7–195.9). NEDOCS score was measured as “extremely busy but not overcrowded” mostly. Table 1 shows the demographic data and distribution of the NEDOCS score. ED staff evaluated the crowdedness as “busy” mostly. Figure 1 shows the answers of the participants about the perception of the ED overcrowding.

A significant difference was found between the ED staff’s crowdedness perception and the NEDOCS score ( $P < .05$ ). ED staff evaluate the crowdedness lower than the NEDOCS score. There was a weak correlation between ED overcrowding perception and NEDOCS score (Spearman correlation coefficient: 0.214). Table 2 shows the relationship between the ED overcrowding perception of the ED staff and the NEDOCS score.

**Table 1**  
Demographic data of the participants and distribution of NEDOCS score.

	% and Median (Min–Max)
Age	25 (20–44)
Women	51
Occupations	
Doctor	16.5
Nurse	14.3
Paramedic	13.8
Intern doctor	41.4
Ward person	14.1
NEDOCS score	99.96 (15.7–195.9)
0–20	0.7
20–60	17.8
60–100	32.0
100–140	31.6
140–180	15.3
>180	2.6

NEDOCS = National Emergency Department Overcrowding Study.



**Figure 1.** The distribution of the emergency department overcrowding perception.

When comparing the ED staff’s overcrowding perception and the occupations, a significant difference was determined ( $P < .05$ ). However, all the occupational groups evaluated the ED overcrowding as “busy” mostly. When the interprofessional relationship was assessed, a low level of concordance was determined (Eta coefficient  $< 0.2$ ). Table 3 shows the relationship between the ED overcrowding and the occupations.

There was a significant relationship between the ED overcrowding perception of the ED staff and the number of on-duty nurses and the intern doctors ( $P < .05$ ) (Table 4). Also, there was a strong correlation between ED overcrowding perception and the on-duty nurse count (Spearman correlation coefficient:  $-0.77$ ). ED staff’s overcrowding perception was decreasing when the on-duty nurse count increase 3 to 4. However, no significant relationship was determined between the ED overcrowding perception and the number of on-duty doctors and ward persons ( $P > .05$ ). The ED overcrowding perception and the on-duty paramedic count couldn’t be assessed because the on-duty paramedic count was the same in each shift.

**4. Discussion**

NEDOCS score was first described in 2004, and after that, it was used in many EDs. But, the acceptability results of the NEDOCS

score were mixed in the literature and, in our study, we decide to test NEDOCS score usability in our ED. We found a significant difference between the NEDOCS score and the crowdedness perception of the ED staff ( $P < 0.05$ ). NEDOCS score was higher than the ED staff’s crowdedness perception, and the correlations were weak. We can say that the NEDOCS score overestimated the crowdedness and did not reflect the ED crowdedness. Similarly to our results, Strada et al and Romero et al, compare NEDOCS score and health care professionals’ perceptions and found that the NEDOCS score overestimates the ED crowdedness.<sup>[23,24]</sup> Also, Wang et al, found that the NEDOCS score is not applicable for extremely high-volume ED setting.<sup>[5]</sup> It is possible to assert that the NEDOCS score is not a suitable scoring system for EDs, which are similar to our ED. On the other hand, Boyle et al found that NEDOCS is suitable for a variety of English hospitals.<sup>[25]</sup> Different studies in different EDs showed mixed results for the usability of the NEDOCS score. Further studies needed to standardize the measurement of overcrowding in the EDs.

In our study, the NEDOCS score was generally found at higher values than the staff’s perception of crowdedness. During the study, the NEDOCS score’s  $W_{admit}$  (the longest boarding time of patients waiting for admission) parameter was longer than 24 hours. So the calculated NEDOCS score was higher. In the study by Derlet et al, it was found that waiting in the ED for a long time caused overcrowding.<sup>[26]</sup> We can stress that as the reason why the NEDOCS score was higher than the crowdedness perception of the ED personnel. While  $W_{admit}$  causes higher NEDOCS scores, it did not affect the ED staff’s perceptions. Also, Romero et al found that when the NEDOCS score is equal to 5 or more, ED staff underestimate the overcrowding.<sup>[24]</sup> It is possible to say that ED staff sometimes may underestimate the overcrowding or working in a crowded ED for a long time may increase the ED staff’s overcrowding perception threshold.

Also, a significant difference was determined between the ED overcrowding and the occupations in our study ( $P < .05$ ). In addition, the eta coefficient calculated to assess the interprofessional relationship between the occupational groups was measured as  $< 0.2$ . In this case, it can be said that there was a weak correlation between the occupational groups. In the study

**Table 2**  
The relationship between ED overcrowding perception and NEDOCS score.

		NEDOCS score						Total	p/R
		0-20	21-60	61-100	101-140	141-180	>180		
ED overcrowding perception (n/%)	Not busy	19	246	232	186	73	17	773	<.001 .214*
		2.5	31.8	30.0	24.1	9.4	2.2	100.0	
	Busy	2	174	364	353	165	27	1085	
		0.2	16.0	33.5	32.5	15.2	2.5	100.0	
	Extremely busy but not overcrowded	0	77	191	203	94	13	578	
		0.0	13.3	33.0	35.1	16.3	2.2	100.0	
	Overcrowded	0	64	189	185	90	21	549	
		0.0	11.7	34.4	33.7	16.4	3.8	100.0	
	Severely overcrowded	0	11	46	70	53	6	186	
		0.0	5.9	24.7	37.6	28.5	3.2	100.0	
	Dangerously overcrowded	0	2	8	22	17	1	50	
		0.0	4.0	16.0	44.0	34.0	2.0	100.0	
Total		21	574	1030	1019	492	85	3221	
		0.7	17.8	32.0	31.6	15.3	2.6	100.0	

ED = emergency department, NEDOCS = National Emergency Department Overcrowding Study  
\* Spearman correlation coefficient.

**Table 3**  
**Relationship between ED overcrowding perception and occupations.**

		Occupation (n/%)					P
		Doctor	Nurse	Paramedic	Intern	Ward Person	
ED overcrowding perception	Not busy	84	105	98	397	89	<.001
		15.8	22.9	22.0	29.8	19.6	
	Busy	153	142	194	419	177	
		28.9	30.9	43.5	31.4	39.1	
	Extremely busy but not overcrowded	104	83	46	280	65	
		19.6	18.1	10.3	21.0	14.3	
	Overcrowded	119	75	91	173	91	
		22.5	16.3	20.4	13.0	20.1	
	Severely overcrowded	52	32	16	55	31	
	Dangerously overcrowded	9.8	7.0	3.6	4.1	6.8	
18		22	1	9	0		
Total		530	459	446	1333	453	
		100.0	100.0	100.0	100.0	100.0	

ED = emergency department.

Wang et al, they found moderate-to-strong agreement between the health care providers.<sup>[5]</sup> Also, Strada et al and Anneveld et al found a weak correlation between the occupational groups similar to our study.<sup>[23,27]</sup> We could not find a relationship or correlation between occupational groups and ED overcrowding perception in the statistical analyses, but all the occupational groups make similar evaluations in the perception of the ED overcrowding. All the occupational groups evaluated the ED overcrowding mostly as “busy”. The ED overcrowding was evaluated mostly as “busy” by the intern doctors. A great majority of the participants were the intern doctors (n=1333). Due to the working conditions and the fact that they are still in training, their responsibilities are less than those of other staff. The intern doctors, who have less workload, as they outnumber other groups, and they have less responsibility, spend the remaining time in the resting rooms outside of the ED. This leads them to feel the ED overcrowding less. For this reason, they may affect the study results as the overcrowding was felt less.

In our study, no significant relationship was determined between the number of the on-duty doctors and ward persons and the crowdedness perception in ED ( $P > .05$ ); but, a significant difference was determined between the number of the on-duty nurses and the intern doctors and the crowdedness perception ( $P < .05$ ). In the study by Hoot et al, it was concluded that the inadequate number of personnel increased the ED overcrowding.<sup>[28]</sup> In the study by Derlet et al, it was found that the insufficient number of experienced nurses caused the ED overcrowding.<sup>[29]</sup> After being diagnosed, the patients who stay in the ED for hospitalization are treated as service patients. Those patients’ workload was less than the other ED patients’ for the doctors and ward persons, but the patients waiting for hospitalization in the ED still have a severe workload for the nurses and intern doctors. Also, in the study Romero et al mentioned that the ED nurses have closer contact with the patients and feel the overcrowding more accurately.<sup>[24]</sup> Therefore, a significant difference was determined between the number

**Table 4**  
**The relationship between ED overcrowding perception and on-duty nurse and intern count.**

		On-duty nurse count <sup>†</sup> (n/%)		p/R		On-duty intern count <sup>‡</sup> (n/%)					p/R
		3	4	0.001	8	9	10	11	12	<.001	
ED overcrowding perception	Not busy	706	67	-0.77*	34	59	415	100	165	.049*	
		23.3	35.3		22.8	35.5	23.7	25.1	21.8		
	Busy	1020	65		56	47	606	118	258		
		33.7	34.2		37.6	28.3	34.6	29.6	34.1		
	Extremely busy but not overcrowded	547	31		36	28	292	83	139		
		18.0	16.3		24.2	16.9	16.7	20.9	18.4		
	Overcrowded	529	20		21	22	322	62	122		
		17.5	10.5		14.1	13.3	18.4	15.6	16.1		
	Severely overcrowded	179	7		2	9	90	32	53		
		5.9	3.7		1.3	5.4	5.1	8.0	7.0		
Dangerously overcrowded	50	0	0	1	26	3	20				
	1.6	0.0	0.0	0.6	1.5	0.8	2.6				
Total		3031	190	149	166	1751	398	757			
		100.0	100.0	100.0	100.0	100.0	100.0	100.0			

ED = emergency department

\* Spearman correlation coefficient.

<sup>†</sup> On-duty nurse count in the shift.

<sup>‡</sup> On-duty intern count in the shift.



of on-duty nurses and intern doctors and crowdedness perception. As the number of the on-duty paramedics in the ED was the same in each shift, the relationship between the number of the paramedics and the crowdedness perception could not be commented.

#### 4.1. Limitations

The first limitation of this study was voluntary participation. The participation proportion is good (120 of 130 ED staff) but did not cover all the ED staff. The second limitation of this study is this is a single-center study. We need larger multicenter studies for standardizing the measurement of ED overcrowding. Also, the study duration was 5 week period, and we know that ED crowding changes with day time or night shift, the weekday, and the season. Our study covers day time and night shifts and every day of the week, but it could not cover every season. The crowding level can change with the season, and especially in winter, the patient number could reach high levels. We need studies which cover all of the days and seasons. Another limitation of the study is the empty waiting room. We could not calculate the NEDOCS score because of the empty waiting room. If we calculate it, we will find higher scores wrongly, and this will lead to calculation bias and affect our results wrongly. We exclude 05:00 surveys to avoid bias. We think an empty waiting room is the biggest limitation of the NEDOCS score. The other limitation of the study was the abnormal distribution of the occupations. The intern doctors' survey count was 41.4% of the surveys, and we think this may affect the results. Researchers should consider the distribution of the occupations carefully for further studies.

#### 5. Conclusions

The NEDOCS score is not suitable for evaluating the overcrowding for EDs, which are similar to our ED. For decreasing ED overcrowding, we should increase on-duty emergency nurse and intern count and reduce waiting time in ED for admission. In this regard, there is an urgent need to constitute local hospital and also public health policies to satisfy the increasingly ED's presentations. Also, further large studies needed to standardize the measurement of overcrowding in the EDs.

#### Author contributions

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