ORIGINAL ARTICLE

A New Model in Reducing Emergency Department Crowding: The Electronic Blockage System

Acil Servis Kalabalığını Azaltmada Yeni Bir Model: Elektronik Blokaj Sistemi

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SUMMARY

Objectives

Emergency department (ED) crowding is a growing problem across the world. Hospitals need to identify the situation using emergency department crowding scoring systems and to produce appropriate solutions.

Methods

A new program (Electronic Blockage System, EBS) was written supplementary to the Hospital Information System. It was planned that the number of empty beds in the hospital should primarily be used for patients awaiting admission to a hospital bed at the ED. In the presence of patients awaiting admission at the ED, non-urgent admissions to other departments were blocked. ED overcrowded was measured in the period before initiation of EBS, the early post-EBS period and the late post-EBS period, of one-week's duration each, using NEDOCS scoring.

Results

NEDOCS values were significantly lower in the early post-EBS period compared to the other periods ($p<0.0001$). Although outpatient numbers applying to the ED and existing patient numbers at time of measurement remained unchanged in all three periods, the number of patients awaiting admission in the early post-EBS period was significantly lower than in the pre-EBS and late post-EBS periods ($p=0.0001$, $p=0.001$).

Conclusions

EBS is a form of triage system aimed at preventing crowding and ensuring the priority admission of emergency patients over that of polyclinic patients. In hospitals with an insufficient number of total beds it can be used to reduce ED crowding and accelerate admissions to hospital from the ED.

Key words: Emergency department; National Emergency Department Overcrowding Study; NEDOCS; overcrowding.

ÖZET

Amaç

Acil servis kalabalığı tüm dünyada giderek yaygınlaşan bir sorundur. Hastanelerin acil servis kalabalık ölçütlerini kullanarak durum tespiti yapması ve uygun çözüm önerileri üretmeleri gereklidir.

Gereç ve Yöntem

Çalışmamızda Hastane Bilgi Yönetim Sistemine ek bir program (Elektronik Blokaj Sistemi, EBS) yazıldı. Buna göre hastanede bulunan boş yatakların öncelikli olarak acil serviste yatış bekleyen hastalar için kullanılması planlandı. Acil serviste yatış bekleyen hasta varken, ilgili servislere yapılacak acil olmayan poliklinik yatışları bloke edildi. EBS başlamadan önceki dönem, EBS sonrası erken dönem ve EBS sonrası geç dönemde birer hafta boyunca NEDOCS skorlaması ile acil servis kalabalıklığı ölçüldü.

Bulgular

Elektronik blokaj sistemi sonrası erken dönemde diğer dönemlere göre NEDOCS değeri anlamlı olarak daha düşük bulundu ($p<0.0001$). Her üç dönemde de acil servise başvuran günlük hasta sayısı ve ölçüm anında mevcut olan hasta sayısı değişmediği halde, acil servis içinde yatış bekleyen hasta sayısı EBS sonrası erken dönemde, EBS öncesi ve EBS sonrası geç döneme göre anlamlı olarak daha azdı ($p=0.0001$, $p=0.001$).

Sonuç

Elektronik blokaj sistemi, acil hastaların poliklinik hastalarına göre öncelikli olarak hastaneye yatışını sağlayan, kalabalığı önlemeye yönelik bir çeşit yatış triajı sistemidir. Hastanedeki toplam yatak sayısının yeterli olmadığı hastanelerde, acil servis kalabalığını azaltmak için acil servisten hastaneye olan yatışları hızlandırmak amacıyla kullanılabilir.

Anahtar sözcükler: *Acil servis; National Emergency Department Overcrowding Study; NEDOCS; kalabalık.*

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Introduction

Overcrowding occurs when no inpatient beds are available in hospital as a result of too many patients with non-urgent medical conditions seeking emergency care.[1] Emergency department (ED) overcrowding is an increasing problem worldwide. Overcrowding is correlated with several negative outcomes, such as increased in-hospital death rates, prolonged treatment times, a rise in preventable medical errors, patients leaving without receiving medical advice from a physician or without being examined in the ED, and repeated applications to hospital.[2,3]

Among the reasons for ED overcrowding are an insufficient number of hospital beds, a rise in ED applications, excessive critical patient numbers, an insufficient numbers of nurse, delayed consultations, delayed radiological examinations, and a shortage of ED physical space.[4]

There are no globally accepted standard criteria for measuring ED overcrowding. However, five main scoring systems have been employed in studies regarding ED overcrowding. [5-9]

1. Emergency Department Crowding Score, EDCS

2. Real Time Emergency Analysis of Demand Indicators Score, READI

3. Emergency Department Work Index, EDWIN

4. National Emergency Department Overcrowding Study, NEDOCS

5. Work Score

Hoot et al. compared overcrowding scoring systems and reported that EDWIN, NEDOCS and Work Score provided powerful prediction of emergency service overcrowding, with negative predictive values of approximately 94%.[10]

A new strategy has been introduced with an aim to reduce the overcrowding in the our ED and accelerate turnover called the Electronic Blockage System (EBS). The main principle of the EBS is to prioritize, patients awaiting admission to the ED. For example, patients that are waiting clinical admission within the ED are registered and all other admissions outside the ED are blocked in the electronic system.

In order to evaluate the success of the EBS based on the principle of priority being given to patients in the ED in admission and reduce ED overcrowding, our study evaluated ED overcrowding in the pre-EBS and early and late post-EBS periods.

Materials and Methods

Study environment

The Dokuz Eylül University Hospital (DEUH) is one of two universities and four ministry of health training and research hospitals providing tertiary casualty department service in the Izmir with a metropolitan population of approximately 4 million. With its 925-bed capacity, it is the third-largest hospital in the province of Izmir. The DEUH ED served 85,813 patients in 2011. Despite a rise in numbers of patients applying to our hospital ED in recent years, the admission rates from the ED to hospital have declined in relative terms since there has been no change in department/intensive care admission rates (Table 1). The mean age of patients applying was determined to be 46. Eight percent of the patients were able to be admitted, while 4% transferred to another institution or left the ED of their own volition. The majority (87%) were able to be seen at the ED and discharged. The ED harbors 42 beds, consisting of: 1 resuscitation room, 11 monitored observation, 10 observation units, 5 for the trauma, 5 in other areas (ear-nose-and-throat, eye, gynecology, psychiatry) and 10 additional beds. Sixteen beds are monitored and 6 have mechanical ventilators. There are two work shifts in the ED from 08:00 to18:00 and 18:00 to 08:00. Each shift includes one emer-

Table 1. Five-year emergency department admission numbers

Year	Patient numbers	Rise in patient numbers (%)	Percentage of admissions from the emergency department to hospital (%)
2011	85.813	8	8.0
2010	79.438	18	8.0
2009	67.476	22	8.1
2008	55.438	22	8.4
2007	45.326	16	9.6
2006	35.808	26	11.8

gency physician, 5 or 6 emergency residents (ER), 5 nurses, 5 medical students in their final year of school, 4 patient care assistants, and 2 paramedics.

Intervention technique: Electronic Blockage System

Before implementation, a meeting of the Emergency Medicine Coordination Board was held at the DEUH Chief Medical Office with representatives of all the clinical units in the hospital and members of the ED teaching staff. The following decisions were made:

• Empty beds in the hospital "should always and without exception" be used for patients awaiting admission at the ED.

• In the presence of patients awaiting admission at the ED, other admissions to relevant wards (polyclinics, for example) should be stopped by the Hospital Information System (HIS), although admissions are to be permitted once patients waiting at the ED have been admitted.

• At transfers between institutions: if a request for a transfer to a clinical department has come from an external institution, the patient is only to be admitted if there are no patients awaiting admission in the ED.

An additional program to the HIS was written for the implementation of this system. In the program, if there are patients in the ED awaiting admission to the relevant ward, then other non-urgent polyclinic admissions are blocked, and admissions are only permitted once patients in the ED have been admitted.

Study protocol

Once approval had been granted by the Dokuz Eylül University Faculty of Medicine Clinical Research Ethical Committee, the study was performed at the DEUH Adult ED where patients aged 18 and over are accepted. Three different one-week periods were selected for data collection: the pre-EBS period (one week immediately before EBS), the early post-EBS period (one week after EBS) and the late post-EBS period, the first week in the second month after EBS). A questionnaire was given out that consisted of questions evaluating ED overcrowding every day throughout the course of the study (NEDOCS scoring) and questions regarding ED personnel (senior ER and senior nurse and paramedic) perceptions related to overcrowding. The questionnaire was completed every day at 07:00 (time of fewest applications to the ED), 17:00 (time of average ED density) and 22:00 (time of most applications to the ED) and the mean of the values obtained taken. In order to evaluate perceptions of overcrowding, the following scoring system was used; 1- calm, 2- normal, 3- crowded or 4- Severely crowded. Additionally, a senior ER personnel was asked about the ED turnaround and the replies scored 1- fast, 2- normal, 3- slowed or 4- stopped.

Crowding measurement technique

NEDOCS scoring was used for overcrowding measurement.[1]

1. Patient index: Number of existing patients in the ED to ED bed numbers.

2. Admission index: Number of patients in the ED waiting

Table 2. Pre-EBS, early post-EBS and late post-EBS results

	Pre-EBS period*	Early post-EBS period*	Late post-EBS periods*	P**
Number of existing patients	32.0±8.4 (range 17-47)	26.8±7.8 (range 15-42)	31.7±8.4 (range 14-44)	0.074
Number of patients admitted to the emergency department in the previous hour	8.0±5.9 (range 1-21)	7.9±4.6 (range 1-16)	7.7±4.6 (range 0-15)	0.969
Number of patients awaiting admission	11.6±3.4 (range 37-19)	7.2±3.3 (range 2-13)	10.9±2.5 (range 6-16)	0.0001
Longest admit time	196.3±49.6 (range 116-275)	72.1±24.7 (range 26-115)	160.9±30.8 (range 113-218)	0.0001
Number of patients using mechanical ventilator	2.4±0.9 (range 1-4)	2.7±1.1 (range 1-4)	5.8±1.0 (range 4-8)	0.0001
NEDOCS value	196.8±10.3 (range 156-200)	131.0±29.9 (range 88-183)	196.3±10.2 (range 159-200)	0.0001
Mean daily patient number	177	159	162	

*: Mean of 07:00-17:00-22:00 time intervals. **: One-Way ANOVA.

for hospital beds to become available to number of hospital beds.

3. Number of ED patients using mechanical ventilators.

4. Admission time: Longest waiting time among patients awaiting admission to the ED.

5. Registration time: Time spent in the waiting room by the last patient taken for admission to an ED bed.

NEDOCS values were calculated on the basis of our hospital standard emergency bed number of 42 and a total hospital bed number of 925 on the http://www.nedocs.org/ web site. At analysis of scores between 0 and 200 at NEDOCS scoring, 100 points was taken as the cut-off value. Accordingly,

- 0-50 points; calm,
- 51-100 points; busy,
- 101-140 points: crowded,
- 141- 180 points: seriously crowded,
- 181 and above: dangerously crowded.

Statistical analysis

The data collected were recorded onto Statistical Package for Social Sciences (SPSS) 15.0. One-way ANOVA and the Kruskal Wallis test were used to compare means, and significance was set at $p<0.05$.

Results

A number of patients, including those in the ED, awaiting admission to hospital, using mechanical ventilators, waiting the longest time, admitted to the ED in the previous one hour, and mean NEDOCS values at time of measurement in all three periods are given in Table 2.

No significant difference was determined between the groups in terms of existing numbers of patients in the ED and number of patients admitted to the ED in the last hour ($p=0.074$ and $p=0.969$). Examination of numbers of patients awaiting admission at the ED revealed a significantly lower number of patients awaiting admission in the early post-EBS period compared to the pre-EBS and late post-EBS periods ($p=0.0001$ and $p=0.00$, respectively). There was no significant difference between the pre-EBS and late post-EBS periods ($p=0.713$).

Table 3. Mean NEDOCS values by Emergency Department Staff Crowing Perceptions

		Mean NEDOCS Values by Crowding Perceptions				
		Calm	**Normal**	**Crowded**	**Severely overcrowded**	**p***
	n	12	18	24	9	
Doctors		152.1±42.6	164.3±43.9	189.3±19.9	186.8±27.8	0.009
	n	8	17	22	16	
Nurses		155.9±39.5	175.0±39.8	178.2±38.4	178.9±27.6	0.474
	n	16	15	21	11	
Paramedics		162.9±43.5	169.7±41.3	184.8±29.5	179.4±27.7	0.293

*: One-Way ANOVA.

Table 4. Emergency Department Personnel Perceptions of Crowding and Work Turnaround

Pre-EBS	**Early post-EBS**		**Late post-EBS**			**p**
Personnel perception*	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**	
Doctors	2.7	3	2.1	2	2.6	3	0.080
Nurses	2.9	3	2.8	3	2.6	3	0.641
Paramedics	2.5	3	2.4	2	2.4	3	0.960
Perception of Work Turnaround¥	2.8	3	1.8	2	2.4	2	0.000

*: Personnel crowding perception: 1- calm, 2- normal, 3- crowded, 4- severely crowded
¥: Work turnaround perception: 1- fast, 2- normal, 3- slow, 4- stopped

Table 5. Mean NEDOCS Values by Senior Emergency Department Physician Work Turnaround Evaluation

	Mean NEDOCS Values by Work Turnaround Perception				
	Fast	**Normal**	**Slow**	**Stopped**	**Total**
n	8	30	22	3	63
Doctors	122.5±29.6	171.6±37.3	194.6±12.6	199.0±1.7	174.7±36.5

Comparison of mean waiting for admission times of those patients waiting for longest at the ED revealed a statistically significant difference between all three periods (p=0.0001, p=0.0001 and p=0.007, respectively). The period with the shortest waiting time was the early post-EBS period.

Comparison of numbers of patients using mechanical ventilators in the ED revealed no significant difference between the pre-EBS and early post-EBS periods, while the number of patients using mechanical ventilators in the late post-EBS period was significantly higher than in the other periods (p=0.449, p=0.0001 and p=0.0001, respectively).

Comparison of mean NEDOCS values by periods revealed a significantly lower NEDOCS value in the early post-EBS period compared to the other periods (Kruskal Wallis test, p<0.0001, Figure 1).

Comparing mean NEDOCS values by perceptions of crowding of each personnel group in the ED, perceptions of crowding increase as NEDOCS values rise. However, no correlation was determined between NEDOCS values and perceptions of crowding of nurses and paramedics (Table 3).

Comparing ED personnel perceptions of crowding in the pre- and post-EBS periods, no significant internal difference was determined in the doctor, nurse or paramedic groups (Table 4).

Comparing NEDOCS values with work turnaround evaluations of senior ED physicians, as NEDOCS values rose they considered there was a deceleration in turnaround (p=0.0001, Table 5).

Discussion

Overcrowding is a common problem in many EDs. There have been several previous studies on the subject. However, there are still no effective and standard recommendations aimed at resolving the problem of overcrowding.[11] Hospitals produce their own solutions supplementary to nationwide health policies in order to prevent overcrowding.[12] EBS was implemented in our hospital for the purpose of reducing the overcrowding problem.

Although there was no significant variation in numbers of patients applying to the emergency service and existing pa-

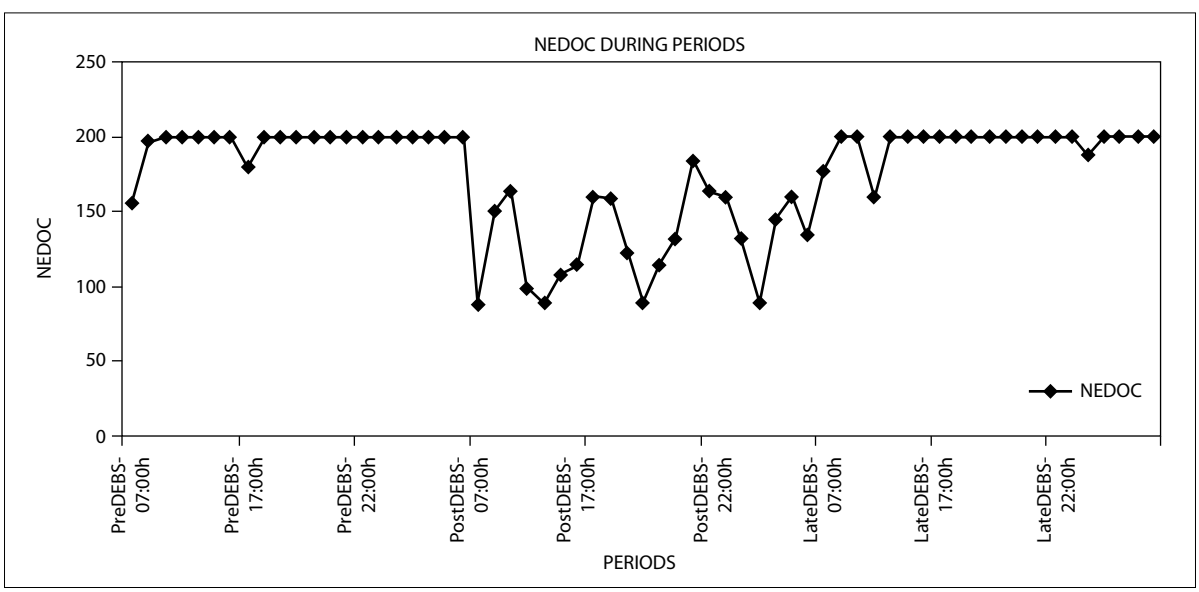

Figure 1. NEDOCS Values by Periods.

tient numbers measured at that time in the department in the early period when EBS was implemented, NEDOCS values declined from dangerously overcrowded to overcrowded (196 and 131, respectively). We ascribe this to patients being admitted to the relevant departments more quickly and the number of patients awaiting admission in the ED decreasing to a lower number of patients using mechanical ventilators in the ED at that time and to a shortening in waiting times among patients awaiting admission in the ED.

Due to the lack of sufficient intensive care beds, the EBS system planned for all admissions from the ED could only be applied to ED admissions. This in turn led to elevated NEDOCS values at times when there were large numbers of patients awaiting intensive care admission. There was no significant variation in numbers of patients applying to the ED and momentarily measured existing patient numbers in the department in the late post-EBS period compared to the pre-EBS and early post-EBS period. This was quite possible due to an increase in the numbers of patients using mechanical ventilators and awaiting intensive care admission. In addition, there was also a rise in existing patient numbers in the ED and patients awaiting admission. This in turn led to NEDOCS values again reaching overcrowded levels in the late post-EBS period. A rise in the number of patients using mechanical ventilators in the ED and in the number of patients awaiting admission to intensive care, even if not using mechanical ventilators, will mean EDs turning into chronic care centers. A solution needs to be found to this, since it will mean a decline in the quality of care given to other patients applying to the ED and requiring first aid. We think that this basic aim of the EBS system can be achieved by increasing the number of intensive care beds and initiating the measure for intensive care.

Crowding perceptions of doctors working in the ED rose in line with NEDOCS values. However, no such relationship was determined for nurses and paramedics. Examination of the effect of the EBS system on ED personnel perceptions of crowding revealed no significant differences within the doctor, nurse and paramedic groups in the pre- and post-EBS periods. Duration of care in the ED is reported to be associated with numbers of ED doctors and nurses and hospital capacity.[13] The reason for the difference in crowding perceptions between doctors and nurses may be that the number of patients per doctor in our ED is sufficient and meets standards, while nurse numbers are inadequate. In addition, despite a partial improvement in NEDOCS values in the post-EBS period, persisting measurement at the 'crowded' level may also affect perceptions of crowding.

Senior ER in our study thought that as NEDOCS values rose there was a slow-down in work turnaround. As crowding in the ED rises, personnel perceptions of crowding worsen and work turnaround decelerates in parallel with this. Increased ED crowding and a slowdown in work turnaround may have led to fatigue, or personnel fatigue may affect perceptions of crowding as a vicious circle, in a vicious circle. However, fatigue levels were not measured in our study.

Limitations

The effectiveness of EBS was measured using only NEDOCS scoring. Other parameters that can measure effectiveness, such as mean durations of hospitalization and hospitalization levels, were not investigated. In addition, EBS was not applied to intensive care admissions. We therefore think that the number of patients awaiting intensive care admission in the post-EBS period may have resulted in the NEDOCS scoring system to overestimate the measurements.

Conclusion

EBS is a form of admission triage system that ensures that ED patients have admission priority over polyclinic patients and is intended to prevent overcrowding. In a hospital where total bed numbers are inadequate, the EBS can be used for the purpose of accelerating admission to hospital from the ED in order to reduce ED overcrowding. Further investigation into the EBS and its practicality and application in different hospitals is need.

Conflict of Interest

The authors declare that there is no potential conflicts of interest.

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