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Original article

Overcrowding and clinical risk in Emergency Departments. A model for the reduction in NEDOCS: preliminary results

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Summary. Overcrowding in Emergency Departments represents one of the main concerns in effective hospital management today. In order to reduce this phenomenon, this study experimented with a new organizational model that exploited available resources, without incurring additional costs. Through the redistribution of hospital beds, it was possible to reduce access blocks in the Emergency Department of the test hospital. The observational period of this study was of 120 days, and daily surveys of crowding were performed at predetermined intervals. The measurement of overcrowding was calculated utilizing the National Emergency Department Overcrowding Score. The findings reveal a significant reduction in overcrowding due to an increase of only 6 beds in the Emergency Department. Currently, it is known that the principle cause of overcrowding is attributed to a lack of hospital beds for inpatients. Numerous studies have shown that through the lengthening of inpatient hospitalizations it is possible to improve crowding levels in Emergency Department. This findings of this study robustly demonstrate that a small increase in the number of available beds available in emergency department leads to a decrease in all variables of the NEDOCS, and in particular, that of the severely and dangerous overcrowding score. (www.actabiomedica.it)

Key words: access block, bed management, crowding

Introduction

Overcrowding in Emergency Departments (ED) has reached alarming levels on a worldwide scale. Recently, several studies have identified the main causes that contribute to this phenomenon and have proposed possible solutions (1, 2). Furthermore, important effects on preventable medical errors in the ED were also highlighted (3).

This present study measured the degree of crowding in the ED, both before and after the introduction of the new organizational layout in bed management. This experimental model consisted in an increase in available beds in the ED so as to reduce the phenomenon of access block, which is one of the main causes of crowding (4). Reducing waiting times for recovery in the ED resulted, in this study, in a noticeable decrease in overcrowding, measured using the National Emergency Department Overcrowding Score (NEDOCS) (5). Other areas of concern are those that occur in prehospital, that cause an increase in the numbers of patients in ED, and those that occur in the patient's inter-hospital transfer. Amongst the later, the prolonged stay of patients in ED, awaiting a bed (access block), is the principle cause of overcrowding. The premise of this study is that an increase in beds, no matter how small, will significantly reduce the effect of overcrowding. This has important implications for guaranteeing effective quality of care, and on the reduction in malpractice cases in EDs (6).

Materials and methods

The scope of this research focused on the Emergency Department of the San Leonardo Hospital in Castellammare di Stabia, Naples, Italy. For some time, the Trust Board has adopted an organizational model based on a system of grouping hospitals (OO.RR.), under one administrative body, thus incorporating the San Leonardo and Gragnano hospitals. The catchment area of these hospitals serves a population of 300,000 people, and approximately 80,000 people enter the ED each year. The study was designed utilizing a 'before-after' type of two samples.

The level of overcrowding was measured using a NEDOCS (5) (Fig. 1). This score evaluates the following parameters: the number of beds in the ED; the number of hospital beds; the number of patients; the number of respirators in use; the maximum waiting time for admission; the number of patients awaiting admission; and the waiting time for a visit after triage. All variables are functions of time *t*. Each item is assigned a score, and the resulting score defines the level of overcrowding in the ED. The following scores relate to the level of overcrowding in the ED: 0-20, not busy; 21-60, busy; 61-100, extremely busy, but not overcrowded; 101-140, overcrowded; 141-180, severely overcrowded; and 181-200, dangerously overcrowded. Five surveys were carried out daily (at 01:00, 07:00, 12:00, 17:00, 20:00), at two separate periods of 60 days each, both before and after the introduction of the new organizational layout: the two samples were observed from 1/2/2014 to 1/4/2014 respectively (sample 1) and from 15/5/2014 to 15/7/2014 (sample 2), and are representative of the flow of patients in the ED. Table 1 shows the characteristics of patients included in this study.

The value t was chosen so as to measure as large a time span as possible that would be representative of patient-flow dynamics in the ED. The item "number of ED beds" consists of 18 beds in the test hospital ED: 8 standard beds, 5 chairs, and 5 stretchers. Conversely, the index "Waiting room wait time for last patient called (In hours)" refers only to patients admitted and assessed by a triage nurse. The resulting findings were represented statistically using Excel 2010. For each sample the total was measured according to the NEDOCS score, identifying the mean, the standard deviation, the correlation coefficient and p-values. Furthermore, a simulation model measuring the flow

Table 1. Characteristics of the study samples

Items	Sample n.1	Sample n.2
Date	1-2-2014/1-4-2014	15-5-2014/15-7-2014
Average age	53	51
No. of admittances	10016	10216
No. of males	4215	4335
No. of females	5801	5881
Code whites	161	219
Code greens	9097	9459
Code yellows	689	466
Code reds	68	71

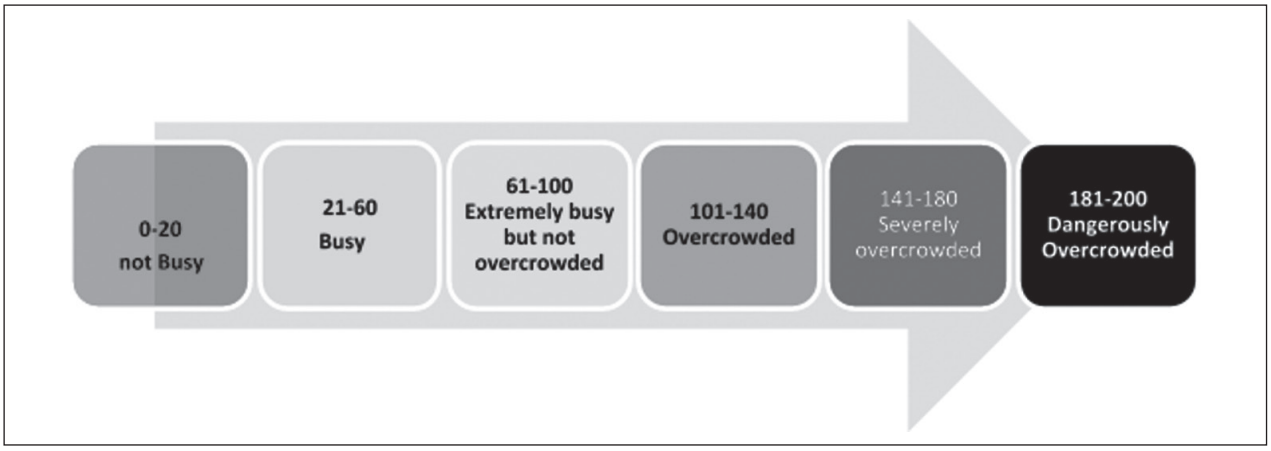

Figure 1. NEDOCS scale

of patients in the ED, applying the Malthus model, was used: it was assumed that the number of people, present in the ED at any one time, t,N(t), increases at a subsequent moment, N(t+h), through a positive constant of proportionality. Through the application of the formula N(t+h)=N(t)+a*h, it was possible to obtain an incremental ratio, in the study, that was applied to a more advanced stage of overcrowding i.e., dangerously overcrowded.

As a result of the introduction of the new organizational model, there was an increase in the number of beds in the San Leonardo Hospital (increasing from 237 to 243), through the utilization of 6 beds at the Gragnano Hospital. The total number of beds at the OO.RR. remained unchanged, though there use has changed. The discharge of patients occurred through a flow, unidirectional and regulated, from the ED towards the inpatients unit (Fig. 2). Hospitalized patients, awaiting a hospital bed, were held in the ED for a maximum of 6 hours, after which they were transferred to the emergency unit of the San Leonardo Hospital. Once past the critical stage, and after having achieved an acceptable hemodynamic and metabolic state**,** parameterized on the Acute Physiology and Chronic Health Evaluation score (APACHE II) (7), patients who needed to complete the diagnostic and therapeutic process were transferred, daily, from the emergency unit of the San Leonardo Hospital to Gragnano. Every day, this structure was committed to conserving 10% of its beds (or a total of 6 beds, or 2 rooms) to accommodate patients transferred from the San Leonardo Hospital, so as to reduce boarding in the ED. This proportion of hospital beds was guaranteed through the modulation and integration of planned admissions with the use of protected discharges, home care, and day hospital. These interventions had the functional aim of optimizing the indices of bed rotation, and the average length of stay. In particular cases, in order to meet predetermined objectives, it was possible to make recourse to temporarily freezing scheduled admissions in Gragnano Hospital. So as to guarantee the efficaciousness of this model, the constant control and support of the Trust Board was required. Such interventions regard the appropriateness of hospitalizations and care pathways (including surgical) of all operational units of the OO.RR.

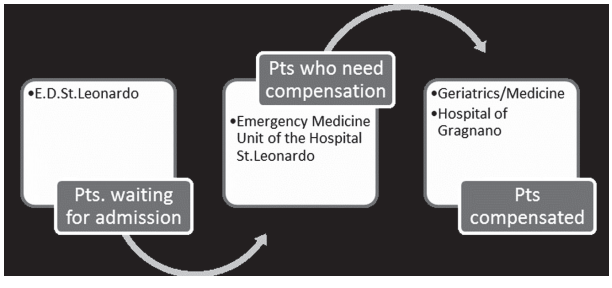

Figure 2. Patients' flow in the proposed model

Results

The findings are represented in figures 3 and 4. The reduction in NEDOCS, in the two samples of this study, was of 10,11% (one score of 53186, with an average of 10637,2, in sample 1; and one score of 47804, with an average of 9560,8, in sample 2). The analysis of the results show, in sample 2 – the group that had benefitted from the increase in beds - a reduction in the *severely overcrowded* score (S.O.) of 34,95% (p=0, 73)

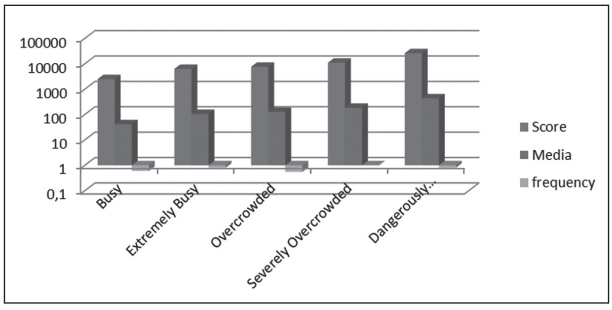

Figure 3. NEDOCS before the new model

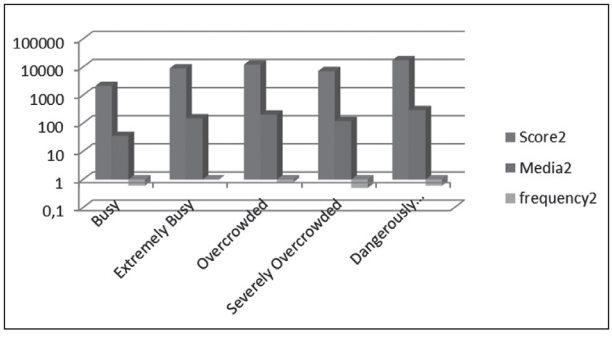

Figure 4. NEDOCS after the new model

and that of the *dangerously overcrowded* score (D.O.) of 32,46% (p=0, 64). The frequency of detection of the two indices, in sample 2, also resulted in a reduction of 53,3% for the S.O. and 20% for the D.O., respectively. When analyzed further, it can be seen that the S.O. indices, in sample 1, showed a score of 10980 (average 183, standard deviation of 62.44 and median of 152), while in the second sample a score of 7142 (average 119.03, standard deviation of 63.41, and median of 72.5). A similar decreasing trend was also observed for the D.O. indices, in the first sample that produced a score of 25914 (average 431.9, standard deviation 231.25, and median of 581.5). In sample 2, there was a score of 17502 (average 291.7, standard deviation 250.14 and median of 360).

As for the "maximum waiting time" for admissions (Longest Admit Time), sample 2 had an average time of 13,33 hours as opposed to an average time of 19,55 hours in sample 1. While waiting times in triage ("Waiting room wait time for last patient called") decreased as a result of the number of beds (1h 30 min versus 2h 50 min). These last two indices had the greatest effect on reducing the NEDOCS. The increase in the number of beds led, not only, to the reduction of the NEDOCS, but also to another variable: the total number of patients in the ED. This reduction may be attributable to increased diagnostics and therapeutics as a result of the increased availability of beds. A further analysis of the report shows that the peak times are Monday mornings and Saturday nights, and between the hours of 10 and 12. Daytime as opposed to nighttime, and the morning as opposed to the evening are traditionally the busiest times. During the observation period of this study (120 days), the left without being seen (LWBS), namely the number of patients who left the ED without being visited by a doctor, was 342 in sample 1 (3,41%) and 212 in sample 2 (2.07%), with a variation of 1,34%.

The evolution in the dynamics of overcrowding was measured using the Malthusian Growth Model. When the ED is severely overcrowded, though the minimum S.O. values of the NEDOCS is 141, a slight increase in the number of patients who access the ED (assuming a constant proportionality of just 0.1), broadly overcomes the D.O. threshold of 181. This variation correlated with an increased risk of medical error in the ED. Applying an incremental ratio, (N(t+h)-N(t)/h=a.N(t), to the data related to the S.O. range, alarming values were obtained far beyond the reference scale for the NEDOCS score (200) in the majority of cases (Fig. 5).

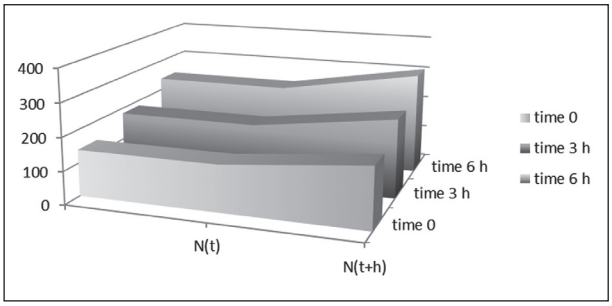

Figure 5. Malthusian Model

Discussion

The ability to measure overcrowding is a prerequisite for the effective planning and development of models that permit specific decision making aimed at solving the issue to be implemented. The basic principle is that "you cannot manage what you cannot measure (8). The NEDOCS scale, one of the various methods employed to measure crowding, offers a sensibility of 81%, a specificity of 87%, and is easily usable in any ED (9, 10). The scope of this study was to identify possible corrective interventions so as to resolve the phenomenon of overcrowding in EDs - without causing any increase in costs. The specific objective of the study was identified in the reduction in access block, through the redistribution of beds in the OO.RR., thus providing an advantage for the ED. Furthermore, it was possible to experiment with a flexible model in the utilization of available hospital beds. By capitalizing on the opportunity offered by this study on the functional reorganization of the OO.RR, it was possible to redistribute a number of seats from the inpatients beds towards deferred urgency permitting an unlocking, albeit partial, of access block in the ED (11, 12). This result was achieved without affecting the performance of the Operating Units for hospitalizations. It is worth noting that, in this study, there is a reduction in the NEDOCS of 10.11%, with an increase of only

six beds. In particular, the improvement was registered in the indices of the most critical areas, the S.O. and the D.O., that more than any indices can influence the quality of care and patient safety. These indices, when very high, can send the whole system into default. For a critical reading of the data, it is clear that this ED still remains excessively overcrowded, and this places the structure at the higher end, with an increased probability of medical error (13). Furthermore, the results do not demonstrate a significant reduction in LWBS: this is probably attributable to the limited duration of the study and the lack of awareness of the audience share with no predisposition to wait. Another critique, that emerges from the study, regards the inefficient management of the waiting room which needs to be remedied immediately, through the implementation of procedures for triage.

There are several observational studies on the measurement of overcrowding in emergency departments. Studies by *Salehi* showed that reductions in waiting times for inpatients reduced access block (14). *Khanna* showed the relationship between the level of bed occupancy in hospitals and crowding (15). However, no study exists that shows the relationship between an increase in inpatients bed and the severely and dangerous overcrowding scale in NEDOCS. This study reveals that, beyond the threshold level, the level of overcrowding, measured with the NEDOCS, has reached alarming levels.

This study shows that, through interventions in the criteria of appropriateness of admission and on the optimization and rationalization of resources (inpatient beds), it is possible to significantly reduce the most critical instance of overcrowding in emergency departments (severely and dangerous overcrowding scale of NEDOCS).

We can view the results from this study in a positive light in that the data confirm the importance of the interventions aimed at exploiting the available resources: the search for a virtuous synthesis between quality and cost can be successful, even in times of economic crisis and spending reviews (16, 17).

These results were achieved, in our case, with ideal conditions representative of a small networked hospital reality, at no extra cost. However, the ability to increase the number of available beds, with only a small initial intervention, also in more complex hospital realities, can improve the degree of crowding in an emergency department.

The encouraging preliminary results should, however, be confirmed over a longer time scale (at least one year) and be cross checked with reports referred by the DRG Diagnosis Related Group(DRG), with the waiting list times and performance indices of the other units involved in this study. If these results are confirmed, the proposed model could represent a valid system for the efficient elaboration of management plans and the flexibility of overcrowding in EDs in hospital management.

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