Digital Queuing System in Emergency Department Management

Behrad Ziapour

Assistant professor and Emergency Medicine specialist, Ahvaz Jundishapur University of medical sciences, Ahwaz, Iran

Mohammad Faramarzi (✉ m.faramarzi89@yahoo.com)

Medical Student Research Committee & Social Determinant of Health Research center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

Mohammad Bahadoram

Medical Student Research Committee & Social Determinant of Health Research center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

Mohammad-Reza Mahmoudian-Sani

Thalassemia and Hemoglobinopathy Research Center, Research Institute of Health, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

Fatemeh Javanmardi

Department of Biostatistics, School of Health, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

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Abstract

Background

The long-standing challenge of emergency department (ED) overcrowding facing central hospitals is often aggravated once inadequate human resources mandate collaboration by companions in terms of laboratory sample transfer, patient transfers within health care facility, or so on. In this study, a digital queuing system (DQS) was developed and evaluated based on the overall goal of triage; thereby, emergency physicians could call companions into the ED, solely on the time they were required to cooperate.

Materials and Methods

To this end, patient arrivals into the ED, wherein this trial was conducted in, were classified using the Emergency Severity Index (ESI) (Version 4) as a five-level ED triage algorithm. Accordingly, patients with triage levels 3 and 4, typically accounting for the majority of the ED overcrowding were included in this trial. At the time of reception, the DQS was also recruited to locate their companions in two different queues. Subsequently, physicians recalled each companion from a station inside the ED, precisely on the time that their patients were being visited. Consecutively, the medical staff filled questionnaires on 30 shifts without the DQS as the control group and on 50 shifts with the DQS as the case group. They correspondingly utilized the Relative Chaos Scale (RCS) to quantify the levels of tension in their shifts from 1 to 10 and to report it in the questionnaires.

Results

The implementation of the DQS could significantly mitigate the RCS reported by either nurses or residents or interns ($p < 0.001$).

Conclusion

It was concluded that DQSs in EDs seem as strong potential tools, which can be developed in accordance with the overall goal of triage. Such modified DQSs can further assist in ED overcrowding control, keeping companions out of EDs until the exact time they are needed.

1. Introduction

Emergency department (ED) overcrowding has been a management challenge for a long time, particularly facing central hospitals in large cities. This problem manifests itself more prominently in developing countries. In fact, the condition of such EDs lies within the definition of internal disaster, which is applied to situations wherein available resources in hospitals cannot meet clients' medical demands (1). The crisis is aggravated in particular when companions are recruited to transfer patients and laboratory samples or to perform documentation and admission processes. Presence and commutes by these agitated companions may further intensify the chaos, potential fights, and even dissatisfaction. In turn,

such an unsecure atmosphere interferes with proper care given by medical staff (2, 3). In this line, digital queuing systems (DQSs) have been successfully exercised for years in chaos management of either banks or medical clinics (4). However, EDs have never practiced them because the first visit time cannot be solely determined by patients' arrival time, but influenced by the levels of severity of their conditions. This is regulated by triage, as a system primarily employed to prioritize allocation of resources and medical care to victims of wars and natural disasters (5, 6). Nowadays, modified forms of this system are being used to classify and allocate resources and medical care to patients entering hospitals. Triage also helps decide whose first visits must be prior to another. In this respect, there are a few studies discussing digital triage, also called e-triage, which means that patient information is digitally recorded and the computer determines the triage level as an output. However, this is never of assistance in chaos management versus what is expected from the new model designed in this study. Accordingly, a DQS was firstly developed in accordance with the overall goal of triage and then the efficiency of this DQS was evaluated in ED overcrowding control in an analytic approach.

2. Methods

2.1. Study Design and Setting

The present study was a (medical administrative) trial in an ED of a teaching (central) hospital with an annual input of more than 100,000 patients. This study was also a case-control research conducted in Golestan Teaching Hospital located in the city of Ahvaz, the capital city of Khuzestan Province in southwestern Iran. At the recall time, the patients or the companions or both might be unavailable or out of the ED for imaging or requesting the results. Pressing the repeat bottom, the physicians could recall the patients up to three times. If no one appeared over these three recalls, physicians could set the absent number to be recalled after five new patients in the queue by pressing the absent bottom. Patients' triage levels might also change on different reasons while they were residing in the ED. To prevent any disturbances in the DQS functioning, all levels of adjustments at all times were possible just through a request form sealed by the physician in charge. Based on this request, the receptionist would issue a new number of the new level. The panel used in station 3 also had a numerical key in addition to the ones explained in Fig. 2, for stations 1 and 2. This could make the DQS manual feeding possible for ticket number of the patients whose files had been completed and formed according to the time that files were ready for re-evaluation and not based on the sequence numbers in stations 1 and 2. Once reaching the number 200 in station 1 and number 500 in station 2, the DQS needed to be reset to launch the ticket number 001 in station 1 and 201 in station 2. The recalls of the tickets with an unexpectedly smaller number could thus cause confusion among companions, especially during ED overcrowding peak hours. Therefore, system-resets were left to the least crowded hours (namely, 5 a.m.). At this time, emergency physicians could discard tickets of the few present patients in the ED and request new tickets for them, according to their triage levels. Totally, in this DQS, tickets numbered 001 to 200 were devoted to patients who had been labeled as level 3 and tickets numbered 201 to 500 were assigned to those labeled as level 4.

2.2. Participants

The triage algorithm used in this center was the Emergency Severity Index (ESI) (Version 4) in which the patients were classified based on the severity of their conditions and the assumed number of resources they needed. Patients labeled as levels 1 or 2 had accordingly critical conditions mandating rapid assessment and treatment in the cardiopulmonary resuscitation (CPR) room. On the other side, patients of triage level 5 were the least urgent groups who could wait as outpatients for their first visits in the fast track area. Thus, in this study, levels 1, 2, or 5 were excluded and patients labeled as levels 3 or 4 were included in the DQS. In practice, triage levels 3 and 4 accounted for the majority of patients contributing to ED overcrowding and chaos. Of note, work shifts were mainly 12 hours in this center. Therefore, information regarding 30 (12-hour) shifts was collected as the control group before installing the DQS in the ED and after installing the DQS, the information about 50 shifts was collected as the case group. The study protocol was further approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

2.3. Data Collection

The information about work shifts was entirely extracted from questionnaires filled by the medical staff, including emergency medicine residents, interns, and nurses. In this questionnaire, they were asked to fill in the form with a number from 1 to 10, based on the most chaotic shifts they could remember in their career as 10 and the least chaotic ones as 1. Then, scores 10 – 7 were considered as the worst chaotic shift, scores 6 – 3 indicated medium chaos, and scores 3 – 1 were taken as best shifts with the least chaos. This variable was named the Relative Chaos Scale (RCS) and was implemented to quantify tension and chaos ratio during work shifts. During each shift, levels of satisfaction from five randomly selected patients were recorded in a scale with items of “not acceptable, indifferent, and acceptable”. As shown in the flowcharts of Figs. 1 and 2, the DQS attempts to keep the entire companions out of the ED treatment area, in a waiting room or similar places, until the exact time they are recalled to collaborate in fetching a blood bag or transferring patients for imaging, ultimate disposition, or so on. Later, laboratory and imaging results could be delivered by the companions into a box, previously applied out of the ED treatment area. This box was also emptied by the staff in regular intervals and the results were enclosed to the related files.

2.4. Statistical Analysis

The sample size in this study was calculated by considering a confidence interval (CI) of 95% and a test power of 80%. With regard to 20% exclusion, 30 and 50 patients were respectively enrolled in the case and control groups to increase the power of the study. Statistical analyses were further performed using the SPSS Statistics software (version 18) (SPSS Inc., Chicago, IL, USA). The categorical data were accordingly reported by frequency and percentage and the quantitative continuous data were indicated by mean $\pm$ standard deviation (SD). Moreover, analysis of variance (ANOVA) was employed to compare the significant difference between work shifts and to adjust the number of patients as confounders. P-values less than 0.05 were considered as the significance level.

3. Results

In this study, 30 work shifts without the DQS as the control group and 50 work shifts with the DQS as the case group filled the questionnaires. Work tension was also high between all the medical staff and it was worst before installing the DQS. As indicated in Table 1, the mean score of the RCS was more than 6, but work tension for the residents became low after installing the DQS and the mean score of the RCS was 2.63 (less than 3), known as the least chaos. However, work tension was medium (namely, between 3 and 6) for nurses and interns.

Table 1
Descriptive statistics of participants

	Before installing DQS		After installing DQS	
	Mean $\pm$ SD	Frequency (%)	Mean $\pm$ SD	Frequency (%)
Resident	7.06 $\pm$ 1.50	-	2.63 $\pm$ 1.66	-
Intern	7.34 $\pm$ 1.60	-	3.17 $\pm$ 1.70	-
Nurse	6.79 $\pm$ 1.61	-	3.89 $\pm$ 1.40	-
Red-card	162.68 $\pm$ 46.27	-	152.83 $\pm$ 40.65	-
Work shift				
8 a.m. to 8 p.m.	-	26 (52)	-	16 (53.3)
8 p.m. to 8 a.m.	-	24 (48)	-	14 (46.7)

The analysis of covariance (ANCOVA) was also applied to determine the effectiveness of the DQS in reducing work tensions among the ED staff. At first, no significant difference was observed between night and morning work shifts ($p = 0.33$). However, it was determined that the DQS had a significant effect on levels of tensions in nurses after removing the number of patients as confounders ($p < 0.001$). Modeling similarly showed that the use of the DQS would cause a significant drop in the RCS, as reported by the nurses (Fig. 3).

With regard to the residents, no significant difference was initially found between night and morning work shifts ($p = 0.12$). Upon excluding the number of patients as confounders, it was revealed that the DQS had a significant impact on residents' work-related tension ($p < 0.001$). Modeling also showed that the DQS had caused a significant reduction in the RCS as reported by the residents (Fig. 4).

About interns, no significant difference was initially established between the morning and night work shifts ($p = 0.7$). After removing the number of patients as confounders, it was found that the DQS had a significant effect on interns' tensions ($p < 0.001$). Besides, modeling showed that the DQS had led to a significant decrease in the RCS, as reported by the interns (Fig. 5).

4. Discussion

EDs constitute fundamental components in primary care (7). Life-threatening situations, debilitating pains, as well as sudden-onset medical conditions are thus all examples directing patients and their agitated companions towards such departments. In other words, they are seeking a medical care in EDs following a combination of both physical and mental tensions. In this respect, overcrowding is not only an interfering factor with delivery of medical care services, but also a provocative one enough for those confined in tension-inducing atmosphere of EDs (7, 8). Over the past century, available triage systems have partly helped deal with management pitfalls of both field and hospital emergencies (9–12). However, many central EDs, particularly the ones in developing countries, are still dependent on cooperation and presence of companions inside the ED treatment area. This simply ends in ED overcrowding. Accordingly, a DQS was developed and evaluated in this study as an optional triage optimizer to keep these companions out of the treatment area until the exact time of first visits, or later, just in case. Therefore, staff training is a requirement to operate the DQS. However, this seems like a limitation for the DQS, especially when a center needs to run the system over days than weeks. Undoubtedly, the long-term strategy to resolve ED overcrowding stands in improving ED infrastructure and providing sufficient trained human resources to work in such centers.

5. Conclusion

Significant reduction in the RCS in this crowded ED suggested a valuable achievement while using the DQS. The RCS was also closely correlated with levels of work tension. It is expected that emergency physicians and medical staff provide higher levels of care for their patients, having a physically and mentally safer and more peaceful place to work. Analyses also explained that DQSs could significantly succeed in providing such a workplace within EDs. Thus, exploiting DQSs is strongly recommended, especially for EDs facing either lack of human resources or increased number of referrals and requests for medical care services.

Declarations

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Availability of data and materials The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request

Consent for publication Written informed consent was obtained from the patient for publication of this case report and any accompanying images

Conflicts of Interest the authors declare no competing financial interests.

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Figures

Flowchart of triage and waiting no., Launched in digital queuing system

Figure 1

Flowchart of triage and waiting number as launched in DQS

Disposition and decision making flowchart in digital queuing system

Figure 2

Disposition and decision-making flowchart in DQS

Figure 3

Interaction between work shift and effectiveness of DQS among nurses

Figure 4

Interaction between work shift and effectiveness of DQS among residents

Figure 5

Interaction between work shift and effectiveness of DQS among interns