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Process Management Model in the Emergency Department of a University Hospital: Reduction of Patient Waiting Times by Changes in Human Resources

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ABSTRACT

Aim and Background: Emergency Department (ED) manages medical, surgical emergencies and victims of accidents, as one of the most important departments of the hospital. The most common problem is the overcrowding and long patient waiting times, as factors of dissatisfaction for patients and associated relatives. The purpose of this study is to design a process management model of ED in the Al-Zahra Hospital, for reduction of congestion and patient waiting times. Materials and Methods: This descriptive and functional research was conducted as a retrospective cross-sectional study. The study population includes 39264 people, referred to the Al-Zahra Hospital. The sample size was estimated 1275 subjects, through systematic random sampling with a confidence level of 99%, but in order to increase the validity of the research, the number of cases was increased to 2515. Data were collected, using a questionnaire and Hospital Information System (HIS). Statistical analysis was performed, using Excel software. The distribution function model was:-0.001 + EXPO (13.2), using the input Analyzer for detection. The three-point distribution was used for all process functions and 1000 runs were performed, using the ARENA software. Findings: Simulation of the existing situation showed that patients' bottlenecks were in the following stations: the first examination by a specialist and writing orders, executing physician's orders by a nurse, registering patient's trials on HIS, and performing Electrocardiogram (ECG).Thus, the 29 solutions to reduce the patient bottlenecks concerning waiting times have been proposed. Subsequently, scenarios were simulated and compared, using the Arena software. Conclusions: The comparison of solutions showed that the most favorable solution is the scenario No 19, decreasing the patient waiting time and stay time, as much as 9.542 and 6.563 percent, respectively. This scenario suggests that instead of having a nurse at each level, two personnel refer the patient to the ward and jointly work between the two levels.

Key words: Management model, process, Emergency Department, Human Resources

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INTRODUCTION

The most important task of the ED, as one of the most important departments of the hospital, is the emergency medical services [1]. ED is important because of the admission of the most voluminous, versatile, and sensitive patients [2,3]. ED manages medical, surgical emergencies and victims of accidents [2]. The hospital without an active ED cannot be regarded as an ideal treatment center and in the event of such a shortfall; this major flaw affects other services of the hospital. On average,57 percent of hospital bed is fed through the ED [4] and approximately 7.25% of the active hospital bed devoted to the ED [2,5]. In the ED because of the seriousness of the patient's

condition, saving life and receiving life-saving treatment in the shortest possible time should be considered a priority [1]. As 75-85 percent of the deaths occur in the first 20 minutes after accidents, if important decisions are made in the first 10 minutes, more death can be prevented [2]. In fact, the speed of service delivery in the hospitals, especially ED has particular importance, leading to a reduction in mortality and morbidity [5]. On the other hand, the most common problem in hospitals ED is overcrowding and long patient waiting times [6]. Inefficient workflow process in three stages of the admission, providing emergency care, and release, causes long waiting and stay time in the ED [7,8]. The previous studies showed that long waiting times affect the quality outcomes and patient satisfaction [8] and one of the causes of discontent of ED care units, is long waiting times for getting services [9]. Emergency congestion also reduces the ability to provide patient care services in the ED [10]. Congestion can be due to delays in the treatment, prolonged patients waiting time, the large number of employees and increased patient flow [11]. Different strategies have been proposed to reduce patient waiting time in hospitals [12]. Kaushal et al. proposed an agent-based simulation tool, in order to study the changes in patient behavior and human resources, in a complex emergency system [13]. Paul et al. showed that insufficient physicians during peak hours, the slow process of patients' admission to the wards, and laboratory and radiology test turnaround times causes reduction of ED through put. The patient stay time was reduced to 18 percent by adding a physician [11]. Zeinali et al. emphasized on the increasing of an application Meta model of decision-making in the ED, and showed that the flow of patient and congestion were improved, by changes in human resources, such as the number of admitters, nurses, residents and beds [6]. French et al. showed that performing triage by a team of nurses only or by a physician- led team in the Emergency Medicine, resulted in decreased wait times. However, there was no significant difference in the length of stay [10]. Salimifard et al. showed that more than 70% of patients stay more than six hours in the ED. The best scenarios will be to assign a three bed-unit in the triage area and "the addition of one nurse" to reduce patient waiting time and decrease the high rate of bed occupancy. The modelhadcreated85% reduction of waiting time for admission, 63%reduction of the total waiting times, also 15% in the hospital bed occupancy [14]. Brenner et al. emphasized on the identification of bottlenecks and studied the optimum number of human resource and equipment, including nurses, physicians and Radiology Technicians. The simulation data showed that there is a need for three additional nurses, in order to reach the optimal clinical outcome [12]. Ajami et al. aimed at reducing the waiting time in the ED at the Ayatollah-Kashani Hospital, using Simulation software and proposed some scenarios [1]. Zare Mehrjerdi et al. proposed six scenarios and concluded that adding a physician and a laboratory staff to the second shift and a laboratory staff to the first shift, have reduced patients' length of stay up to 22% in a university-affiliated hospital [15].

The ED of Al-Zahra Hospital is one of the most visited national emergencies, due to a variety of opportunities for specialty and sub-specialty services, and as the main referral center for patients in Isfahan province, receives a number of patients from another area and surrounding provinces. Jabbari et al. showed that waiting time to provide services in the ED of Al-Zahra Hospital is more than standard, announced by the Ministry of Health and Medical Education and accredited hospitals in the world. Their study aimed to determine the waiting time and to provide appropriate solutions, and it was carried out before the establishment of the triage system and changes in hospital physical space of the ED of Al-Zahra Hospital.

Several strategies were proposed, including prioritization of beds for emergency and non-emergency patients, designating an admission's coordinator, enforcing 30-minute rule for CCU and ICU, creation of the temporary holding unit, direct patient admission, scientific review of the number of beds in the ICU and CCU; in order to prevent and solve the overcrowding issue [7].

The present study aimed to design a process management model of ED in the Al-Zahra Hospital, in order to reduce the patient waiting time and congestion, to create satisfaction among patients and their relatives, and also to provide high quality services. In this study, different solutions were evaluated, using Simulation techniques. Due to the important role of medical staff in providing patientcare and in order to balance the number of emergency situations, this paper presents the impact of changes inhuman resources in the Al-Zahra Hospital for reduction of patient waiting times and ED overcrowding.

MATERIALS AND METHODS

This retrospective cross-sectional study was conducted by a descriptive and functional method. The study population was 39264 subjects, consisted of all patients referred to the Al-Zahra Hospital, in all shifts and days of the week and at different times, during the early November 2013 untilthe end of October 2014. The sample size was estimated, using the following equation:

$$n=(\frac{zs}{s})$$

For 1275 cases through systematic random sampling with a confidence level of 99%, but to strengthen the validity of the research, the number of cases was increased to 2515.Data collection tools were a researcher-made questionnaire and HIS.

The questionnaire had 24 questions regarding the patient characteristics such as case number, age and sex. In addition, it includes information such as type of referral (personal visit or referrals from other centers), visit date, triage level, the patient first visit by a specialist. In term of timing it covers the triage time, admission time, specialty consultation, the time of execution of the specialist order by a nurse, The time of request for medical imaging and the time to perform medical imaging, the time to request lab test for patient, the time for submission of patient's sample to the lab, the time to release the lab test results, the time to request first consultation for the patient, the time of having consultation, the time of physician order for an ECG and the time of performing ECG, the time of transferring patient to a ward and the time of physician order for a discharge from ED or time of leave against medical advice (LAMA), the time of discharge and vacating the bed.

Data collections were carried out in the medical records unit of Al-Zahra Hospital by reviewers, not from hospital staff, in order to avoid potential bias. The questionnaire was modified, using expert ideas (officials and specialists in the ED of Al-Zahra Hospital) and the validity of the data was confirmed by reviewing the patient medical chart at the medical records unit of Al-Zahra Hospital. In addition, the reliability was defined by calculating Cronbach's alpha coefficient, using SPSS software. All information about the variables in the questionnaire was documented in the medical chart at the medical records unit of Al-Zahra Hospital, except the laboratory and some radiology results that were available via HIS. Then, statistical analysis was performed, using Excel software.

Simulation is a simplified model of the real thing, social status or a process. In fact, it is a science and art of building a model, for a process or system to evaluate strategies, and it is a way to find out the results of the proposed ideas, before implementing. Simulation is used in many categories, including modeling to gain insight and knowledge about natural and human systems. The simulation can be used to show the effects and consequences of different circumstances that are not true and also is used to evaluate the impact of existing factors.

The ARENA simulation software package is used for discrete event systems. This software is designed to analyze the impact of major and complex changes in relation to common applications, such as the supply chain, manufacturing, logistics, ware housing, distribution and service systems. The ARENA software helps manage and optimize three important factors in the ED. These three factors are costs, patient waiting time and the number of personnel.

This study was conducted, using the simulation techniques by emphasizing on the long patient waiting times in the ED and the importance of reducing these times, using a cost-effective and efficient approach. A physical model of the real system was designed by the ARENA Software and then the flow of patients in the Al-Zahra Hospital observed by graphics and animations on the screen.

The distribution function model was: -0.001 + EXPO (13.2), using the input Analyzer for detection. The three-point distribution was used for all process functions, and the ARENA software was run 1,000 times. Then, according to the patients' expectations bottlenecks, solutions were proposed and compared, in order to reduce the waiting time, using the ARENA simulation software. This paper examines the impact of implementing solutions for human resource changes, in order to reduce patient waiting times and overcrowding in the ED of Al-Zahra Hospital.

RESULTS

The utility output of Input Analyzer Software showed exponential function with a mean time of 13.2 minutes. This means that on average every 13.2 minutes, a patient is admitted to the ED of Al-Zahra Hospital. Patients are classified, according

to condition severity as level 1, 2 and 3; after admission and triage. First level patients, are in a much worse situation and need faster and more urgent services, compared to others and cannot wait to get service. The second level patients have a better situation than the first level patients do, and third level patients also have much better conditions than the previous levels; that is to say, they shall wait to receive medical care. The results showed that the minimum number of patients entered are 59 per 24 hours, of these, the number of first, second and third level patients are equal to zero, 14 and 45, respectively. The maximum number of patients entered is 163 people, among those, 12, 56 and 95are first second and third level patients, respectively. On average, the number of patients entered is equal to 109 people, that 4, 35 and 70are first, second and third level patients, respectively. With regard to patient discharge from the ED, 9% of second level patients and 11% of third level patients as LAMA. Figure 1 shows the patient tracking in all three levels and table 1 shows the current status of the ED of Al-Zahra Hospital, based on the number of personnel.

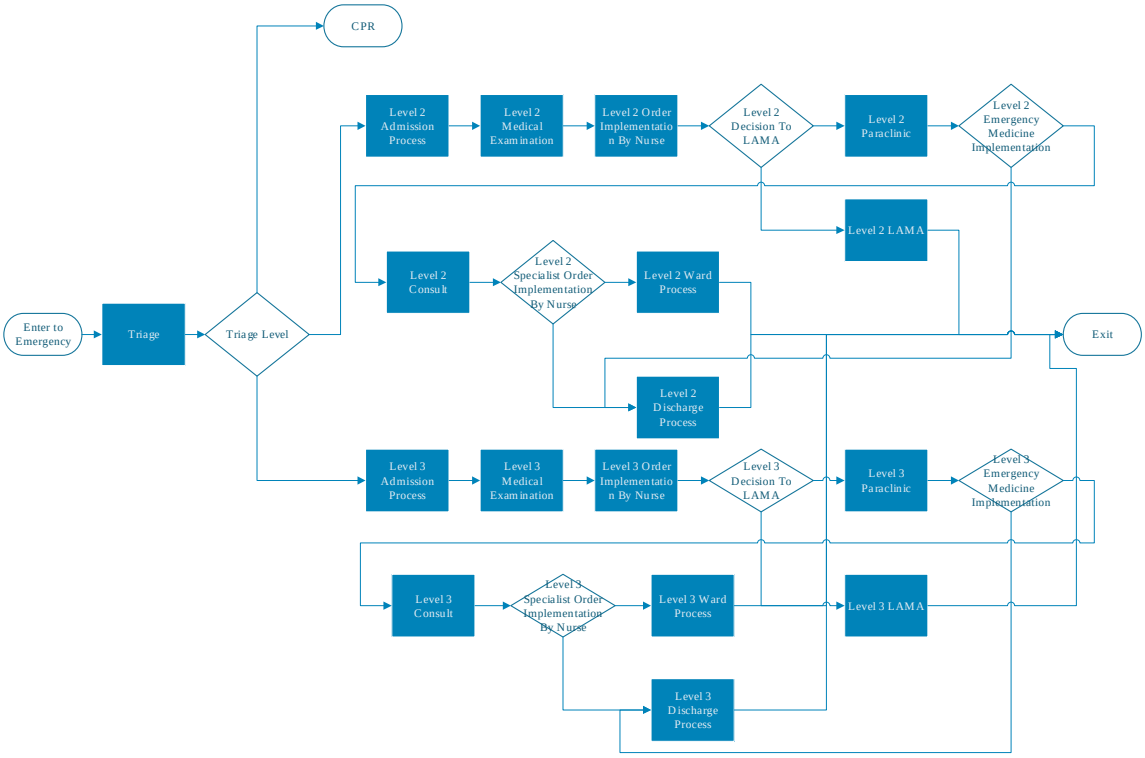

Figure 1: The patient-tracking flowchart in the ED of Al-Zahra Hospital

Table 1: The current status of the ED of Al-Zahra Hospital, based on the number of personnel

Personnel	Level (2)	Level (3)
Emergency Medicine Resident	2	3
Emergency Medicine Specialist	1	1
Nurse	6	6
Personnel of Radiology Unit	9	
Personnel of Electrocardiography Unit	2	
Personnel of Triage Station	2	
Personnel of Central Laboratory	40	
Personnel of Admission Station	2	
Personnel of Discharge	1	
Sample Carrier	2	

After designing and simulation of existing status, model was run 1000 times, and the average patient waiting time for emergency service was identified, as well as the number of patients who were in line for each station, and important bottlenecks were determined. The ED bottlenecks were in the following stations: the first medical contact with emergency physicians and writing orders, executing physician orders by a nurse, patient's registration on HIS, and performing electrocardiogram. Table 2 shows the average waiting times and queues at each station in the present situation (baseline).

Table 2: The average waiting times and queues at each station in the present situation (baseline).

Service stations	Level 2		Level 3	
	The average patient waiting time (minutes)	Queue	The average patient waiting time (minutes)	Queue
Triage	0.0982	0	0.0982	0
Admission	138.46	3	274.37	44
First examination by a specialist and write orders	67.9820	2	341.15	3
Executing physician's orders by a nurse	146.49	7	277.27	9
Radiology	210.66	3	284.61	3
ECG	337.54	7	319.68	3
Lab. Data registration by anurse	48.8092	6	56.3218	4
The sample delivery to the laboratory by sample carrier	4.1038	3	3.9020	3
Releasing the test results	179.42	3	38.7190	1
Consultation	212.60	3	254.61	2
The patient's LAMAwith the personal consent before completing the treatment process	80.2757	1	67.4585	1
Patients Walk-Outafter being discharged by a physician	102.99	3	74.0511	2
The patient's discharge with the personal consent after completing the treatment process	56.4063	0	14.5931	0
Referral to the ward and bed availability	60.0722	3	47.6461	2

To recognize the impact of human resource changes in each emergency services station of the Al-Zahra Hospital, various scenarios were defined, according to the experts in the field. Then, using the ARENA software, each scenario was simulated and the impact of each scenario on patient waiting time was measured in each of the service stations. Twenty-nine scenarios were defined for changing human resources at various stations. The defined scenarios are listed in Table 3.

Table 3: The simulated scenarios

Scenario Number	Scenario
1	Adding one nurse to level 2
2	Adding one resident to level 2
3	Adding two nurses to level 2
4	Adding two residents to level 2
5	Adding one nurse and one resident to level 2
6	Adding two nurses and one resident to level 2
7	Adding one nurse and two residents to level 2
8	Adding two nurses and two residents to level 2
9	Adding one nurse to level 3
10	Adding one resident to level 3
11	Adding two nurses to level 3
12	Adding two residents to level 3
13	Adding one nurse and one resident to level 3
14	Adding two nurses and one resident to level 3
15	Adding one nurse and two residents to level 3
16	Adding two nurses and two residents to level 3
17	Adding someone as discharge personnel for each level
18	Assigning one person for patient transfer to ward instead ofa nurse for each level
19	Assigning two persons for patient transferto ward instead ofa nurse for each level
20	Assigning one person for ECG recording in level 2 and two personsin level 3
21	adding one person forECG recordingfor both levels
22	Assigning a person for laboratory data registration instead of anurse for two levels
23	Assigning a person for laboratory data registration instead of a nurse for each level
24	Adding one nurse and one resident to each level
25	Adding two nurses and one resident to each level
26	Adding two nurses and two residents to each level
27	Adding one nurse and two residents to each level
28	Assigning one person for ECG in level 3 and two persons for ECG in level 2
29	Adding one person to radiology unit

The results of the implementation of eight scenarios, corresponding to the level 2 are shown in Figure 2.

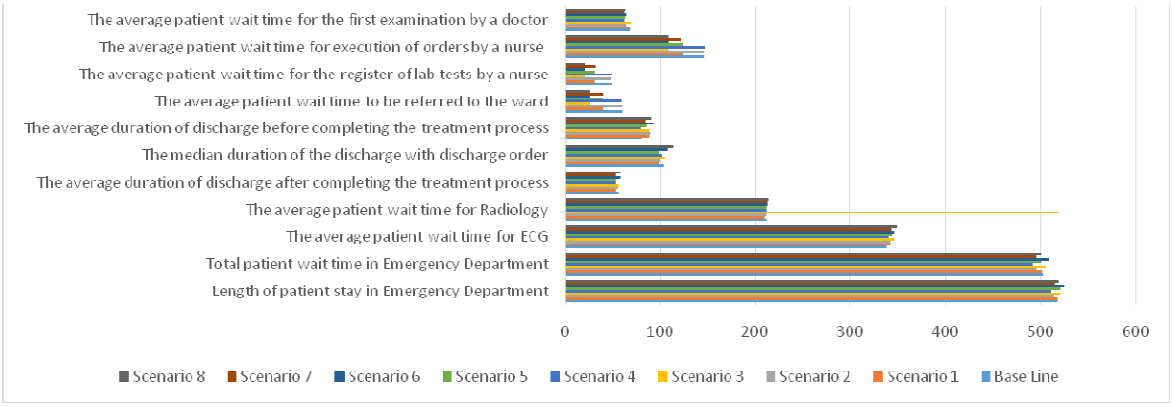

Figure 2: The result of implementation level 2 scenario

Of the eight scenarios, Scenario No. 4 (adding two residents to level 2) is more effective for improving the total patients waiting times and length of their stay.

Figure 3 shows the results of the implemented third level scenarios. The implementation of scenarios regarding level-3 patients showed that scenario No. 12 (adding two residents to level-3), is more effective for reducing the patients waiting times and length of stay.

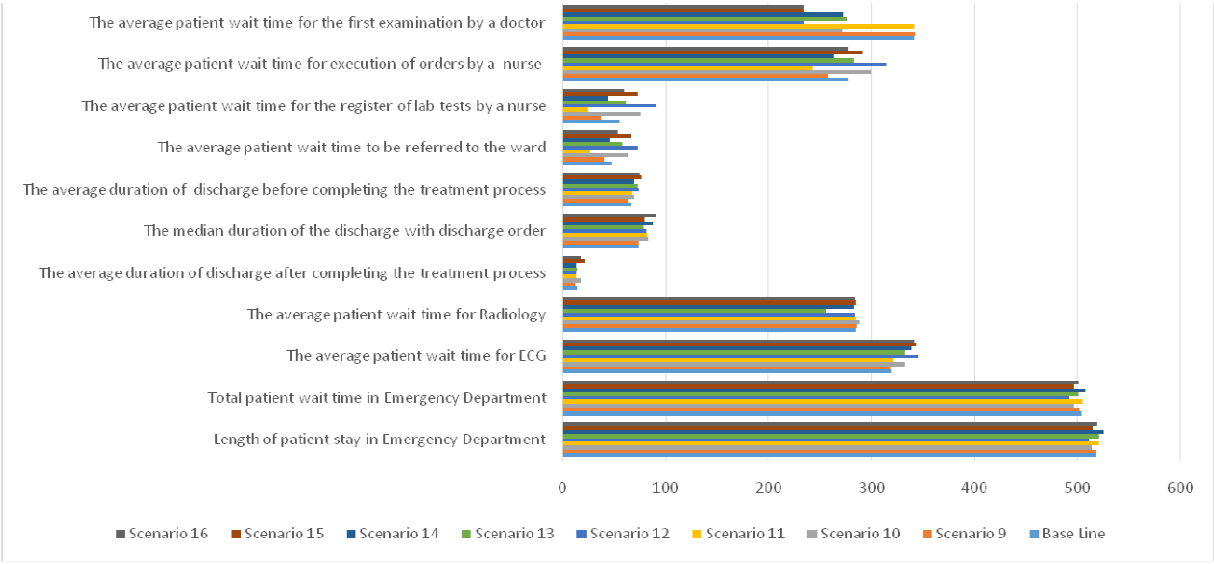

Figure 3: The result of implementation level 3 scenario

The results of simulation of 29 scenarios, with respect to changes in human resources were shown in Figure 4. As the chart shows, the total patient waiting times by running scenarios numbers 1,2, 4, 5, 7, 8, 9, 10, 12, 13, 15, 16, 18, 19, 20, 21, 24, 26, 27, were reduced0.198, 1.391, 2.186, 0.397, 1.391, 0.397, 0.397, 1.391, 2.186, 0.397, 1.391, 0.397, 2.385, 9.542, 2.186, 3.379, 0.397, 0.397, 0.397 percent, respectively, compared to the baseline. In addition, the duration of patient length of stays in the ED by running scenarios 2, 4, 7, 10, 12, 15, 18, 19, 20, 21, were reduced0.772, 1.351, 0.579, 0.772, 1.351, 0.579, 1.737, 6.563, 1.737, 1.930 percent, respectively, compared to the baseline. Thus, the most effective scenarios for reduction of waiting times and length of stay, in the ED of Al-Zahra Hospital are as follows; 1) The scenario No 18: (assigning one person for patient transfer to ward instead of a nurse for each level) with a 2.385 percent

reduction of waiting times, and 1.737 percent reduction in patient length of stay; 2) Scenario No 19 (assigning two persons for patient transfer to ward Jointly, instead of a nurse for each level) with a 9.542 percent reduction of waiting times, and 6.563% reduction of the length of patient stays; 3) Scenario No 21 (adding one person to perform ECG jointly for both levels) with 3.379 percent reduction of waiting times and 1.930 percent reduction of patient length of stays.

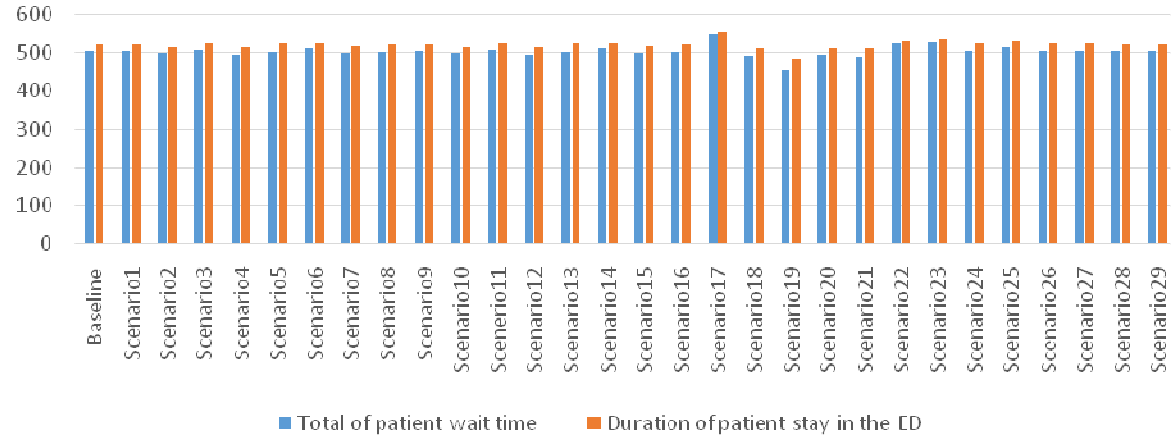

Figure 4: The result of implementation 29 scenarios

Therefore, the optimal scenario is No. 19, reducing 9.542 percent patient waiting time and 6.563 percent patient length of stay. This scenario proposes that instead of one nurse in each level, two persons should be present for patient transfer to ward.

DISCUSSION AND CONCLUSION

The mission of an ED is to provide medical emergency care, and promoting patient turnaround times. The Increased patient length of stay, leads to increased boarding time and bed occupancy rate, and increased medical errors, which in turn, results in patient dissatisfaction, morbidity, and mortality. The results of this study showed utilization of various techniques, such as operations research and simulation, according to circumstances and available resources can help to manage ED overcrowding on a scientific basis, followed by reasonable decision-making to save money and resources.

In this study, we tried to design a simulation model of the actual system performance, with regard to patient wait times, and patient turnaround times in the ED. By identification of important bottlenecks, such as first medical contact with emergency physicians and writing orders, executing physician orders by a nurse, Laboratory data entry into HIS, and recording ECG, this study attempted to resolve these issues; with the emphasis on optimum number of human resources and, as well as the resources' performance by focusing on human resources and incentive program, as one of the key approaches for quality improvement in the organization [15]. The implementation of the proposed scenario shows, patients waiting times can significantly be reduced by making appropriate changes to existing processes at various stations of the ED.

The results of this study are consistent with previous researches, such as the study of Ajami et al. [1], as to reduce patient waiting time at the Kashani Hospital, a trauma center in Isfahan province. In addition, the present study showed that the radiology, laboratory and ECG stations are patients waiting bottlenecks. Our data are consistent with the study of Tabibi et al. [3]. In addition, the results of this study are consistent with the research of Jabari et al., recognizing X-ray, ECG and laboratory stations as patient bottlenecks. While this study is different, compared to the study of Jabari et al., concerning the following two issues; first, their research was conducted before the establishment of the triage system in the ED of Al-Zahra Hospital. Secondly, waiting time was acquired, using the stopwatch, but in the present study, we conducted a retrospective study, to prevent the potential bias of the so-called 'Hawthorn effect'. Zare Mehrjerdi et al. [16] suggested few scenarios, in order to reduce patient wait time, such as adding a

physician and a laboratory technician to the second shift and adding a laboratory technician to first shift. Salimifard et al. [14] suggested adding a nurse and 3 beds in order to reduce patient waiting time.

In this study, solutions for ED overcrowding in a University-affiliated Hospital were proposed, using simulation methods. The most favorable and practical solution is the allocation of two persons for patient transfer to ward, jointly for every levels-2 patient.

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