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SIMULATION OF THE EFFECT OF TEAMWORK IN THE EMERGENCY DEPARTMENT ON PATIENT WAITING TIME AND STAFF EFFICIENCY

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ABSTRACT

Background: Reducing and standardizing the wait time and increasing and smoothing the efficiency of the work of emergency personnel with team work requires predicting its results before the decision. Objectives: With using the simulation tool in this study, we examined the results of teamwork in the emergency department. Methods: This is an analytical and applied research that was carried out in September and November 2018 in the emergency department of Sina Hospital on 160 patients in three shifts in the morning, evening and night. In order to collect the data, interviews with authorities and the standard form of the Ministry of Health in accordance with the objectives of the study were used. At the end, with ARENA software, team work simulated and its effects, in 3 scenarios, predicted. Results: As other studies patients' entrance rate was in Poisson. By reducing the number of FAST section nurses, not only the total outflow of patients did not decrease, but the staff efficiency of this sector increased by 19%. In the second and third scenarios, it was observed that with team performance between acute sections 2 and CPR with priority of CPR and acute sections 1 and fast nurses, patient outcomes increased, waiting time relatively low increased, patient outcomes and staff efficiency of these sections increased in a balanced way. Conclusion: To achieve the desired indicators, teamwork was evaluated positively, but doing things by Teamwork is one of the most difficult and costly decisions that before making these decisions, it's better to predict the results of it in virtual environments.

Keywords: *Emergency, Teamwork, Waiting Time, Staff Efficiency, Simulation*

INTRODUCTION

One of the most important parts of the hospital is the emergency department (ED), whose main task is to provide services in urgent medical conditions (Ajami et al., 2011). This division, as one first contact point for patients with a health care system faces major challenges in providing high quality and timely patient care. Factors such as the shortage of hospital beds for inpatient care and lack of access to outpatient care lead to growing patient numbers and crowding in this department, resulting in longer waiting times and poor service quality for patients (Soremekun, Takayesu and Bohan, 2011). Despite the fact that ED in hospitals is under the pressure of this growing demand, and mismatch between patient demand and ED's capability in most cases is due to suffering from limited financial and human resources (Holden, 2011). In addition, the overcrowding of patients and inability to flex capacity to meet demand increases the working stress and difficulties for care providers and reduces professional ethics among the ED's staff (Koskela and Howell, 2002). The link between ED crowding and mortality is increasingly being recognized. Therefore, interventions such as

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reducing waiting time, improving performance and increasing the efficiency of ED's staff should be emphasized. Complexity and advancing knowledge in the health system have led to gathering of various specialists come together as teams, and provide comprehensive plans for delivering the quality care to patients (Nancarrow et al., 2013). On the other hand, collaboration between different clinical and nonclinical staff effectively, as health care teams can improve patient outcomes, prevent medical errors, improve efficiency and increase patient satisfaction. Therefore team working is considered as one of the most important factors for positive and cost-effective outcomes in the health care organizations (Sexton et al., 2006). Interprofessional teamwork add to efficiency of each staff on patients' treatment.

The smallest error in performance can affect the health and well-being of individuals in health systems organizations including stressful and high-risk hospital departments as emergency because of the diversity and difference in the role of the members, hence in this departments, teamwork has special significance (Zeltser and Nash, 2010; Baker, Day and Salas, 2006).

The concept of teamwork in health care settings based on Xyrichis and Ream analysis is a dynamic process involving at least two health professionals with complementary backgrounds and skills. They have specific goals and efforts to provide services to patients, and these efforts will mainly lead to positive outcomes for patients, staff and organization (Xyrichis and Ream, 2008). Achieving the above-mentioned emergency indicators by teamwork requires methods and tools to predict the results and minimize the risk of error in decisions. The simulation tool is a suitable alternative method with less time spending and lower costs, in comparison with traditional statistical methods. This tool provides an opportunity to examine the effects of different solutions to improve the ED's status and reduces the costs and risks of practical implementation of the solutions (Jacobson, Hall and Swisher, 2006). So, this study is conducted to provide a tool for testing such pre-implementation decisions

Unlike the technical skills that are emphasized in the medical science curriculum, teamwork as a non-technical skill is somewhat intangible and difficult to train and evaluate. Therefore, in this study, we want to show the results of clinical teamwork in the emergency department with the aim of reducing waiting times for patients and increasing staffs' efficiency by simulation tools with different scenarios.

METHODS

This is an analytical applied research that was carried out in September and November 2018 in the emergency department of Sina Hospital a public specialized trauma center with 388 active beds that is one of the largest hospitals of Tehran University of Medical Sciences. It is located in the populated center of Tehran with large number of patients referred to its ED. The study population included all patients who arrived to the ED within two months and a total of 160 samples were selected.

In order to collect data, checklist was used which was designed according to the "Timetable of Emergency Workflow Schedule" of the Ministry of Health and Medical Education of Iran and its reliability was determined by Cronbach's alpha coefficient ($\alpha = 0.93$). In order to obtain a patient entry rate (λ), upon arrival to ED and taking appointment in admission desk, their admission time was recorded. The other sections of the checklist are completed according to how long the patient receives the services (μ). At the end of their visit, the time of discharge

and leaving for the patients from the ED and how they were discharged was recorded. Due to the lack of uniformity of arrivals to the ED, patient arrivals rate in three working shifts (morning of 7-13, evening of 13-19 and night of 19-7) was obtained, and the appropriate sample size for each shift was determined from the total 160 samples.

Other required information was obtained by interviewing the manager and nurses in ED including information about different ED unites, number of service providers and types of their specialties, the time for start and end hour of each working shift. In order to calculate the patient arrivals rate, we recorded the arrival time of patients and working shifts during the different days of the week. Because, the rate of patients' arrival at different shift hours were not the same, so the rate was determined for morning, evening, and night shifts separately. Finally, the average arrival rate for the patients in three working shifts was also calculated.

Checklists data was entered into SPSS software and analyzed by statistical methods. After this step, in order to identify the existing work stations, the simulation models of the ED were designed in the Arena software environment, and after entering the real data in the virtual model and executing it, the workstations were identified in the model. Then, by performing improvement scenarios in the virtual model and comparing the results, the best scenarios were identified.

The control variables in this model included: 1) The number of emergency staff including receptionists, triage nurses, physicians, head nurses, CPR nurses, Fast units' nurses, Acute unit 1 nurses, Acute unit 2 nurses, and nurse assistants. 2) Practiced team working among staff from different units that could help each other. Also, the output variables of the model included waiting time of patients and the efficiency of emergency staff providing services. Finally, the best 3 scenarios are presented in this study.

RESULTS

Descriptive data of the different parts of the ED, the number of service providers, their specialties, the start and end time of each shift, as well as the levels of triage and the type of patients present in each level are presented in Table 1.

The calculated patient arrivals rates were respectively for the morning shift, 90% of the entries from 8 AM to 12 PM; in the evening shift, 80% of the entries from 5 PM to 7 PM and in the night shift, and 80% of the entries from 7 PM to 1 AM. Finally, the average arrival rate for the patients in three working shifts was calculated to be 3.8 patients per hour and it followed the Poisson distribution.

Table 1: working Shift hours, number of staffs, divided by different ED parts and patient types

Working Shifts	Emergency parts				
	Reception and Discharge	CPR (First level of triage Patients)	Acute unit1 (4th and 5th levels of the triage) Patients with low pain and Para clinical need	Acute unit 2 (3th level of the triage) Patients with chest pain, stroke, Medical advice need	Fast unit (2th level of the triage) Patients with trauma, accidental patients require suture

Morning 13-7	One Person	One Head nurse / Shift manager A nurse A nurse assistant	Two nurses	Three nurses	Three nurses
Evening 19-13	One Person	One Head nurse / Shift manager A nurse A nurse assistant	Two nurses	Three nurses	Three nurses
Night 7-19	One Person	One Head nurse / Shift manager A nurse A nurse assistant A nurse assistant is added if necessary	Two nurses	Three nurses	Four nurses

ANALYTICAL FINDINGS

The data from the checklists, which included service delivery length of time at the work stations, were entered to the Arena software. At this stage, an interview was conducted on a variety of states based on changing the number and combination of staffs, as well as performing emergency tasks on teamwork bases, which resulted in: one scenario for changing the number of staff and two scenarios for team working performance.

It should be mentioned that it was possible to provide more and different scenarios based on the equipment variables and major changes for staff in the simulation tool, but their implementation in the real situation were impossible; therefor, providing additional scenarios was prevented.

Results extracted from analysis of service delivery times in the form of ARENA software

Patients average arrival was 2696 patients per month.

In the initial state, along with the number of patients arrivals, we find that the maximum waiting time is for the doctor's initial visit, in the Fast unit and Acute unit1; and the highest efficiency is for the emergency doctor with (94%) and the lowest efficiency is for the head nurse (4%). (Table 2)

Table 2: ED's staff efficiency, and average waiting time and waiting list in queues at in the initial state

Staff	Staff Efficiency (%)	The name of the waiting queue	Average waiting time in the current state (min)	The average number of people in the queue in the current state
Receptionist and Discharge officer	45%	The reception	0/15	0/009
Triage nurse	25%	Triage	0/01	0/001
Physician	94%	Emergency Physician Visit	5/67	0/34
Head nurse	4%	Cardiopulmonary resuscitation (CPR)	0	0

CPR Unit Nurse	5%	Physician Visit in Fast unit	6/74	1/12
Fast unit nurse	17%	Physician Visit in Acute unit1	10/15	4/19
Acute 1 unit nurse	72%	Physician Visit in Acute 2 unit	6	1/03
Acute 2 unit nurse	20%	-	-	-
Nurse assistant	5%	-	-	-

First scenario:

1. *The number of nurses for night shift in Fast unit reduced to three.*

- Average Number of Emergency Patients: 2696 patients per month

According to Table 1, the number of staffs in the different parts of the emergency department are mentioned; we find that the number of nurses of the Fast unit is 4 in the night shift and assume that we don't need 4 nurses per night regarding the entrance rate. In the first scenario, we reduce 1 nurse in Fast unit to continue. In this scenario, the number of patients waiting in queues didn't change, and the average number of patients per month remained constant, but Fast unit nurses' efficiency increased by 19% (Table 3).

Table 3: Human resource efficiency, and average waiting times and number of patients in waiting list in queues at emergency department in the first Scenario

Staff	Staff Efficiency (%)	The name of the waiting queue	Average waiting time in the current state (min)	The average number of people in the queue in the current state
Receptionist and Discharge officer	45%	The reception	0/15	0/009
Triage nurse	25%	Triage	0/01	0/001
Physician	94%	Emergency Physician Visit	5/67	0/34
Head nurse	4%	Cardiopulmonary resuscitation (CPR)	0	0
CPR Unit Nurse	5%	Physician Visit in Fast unit	6/74	1/12
Fast unit nurse	19% (2% increased)	Physician Visit in Acute 1 unit	10/15	4/19
Acute 1 unit nurse	72%	Physician Visit in Acute 2 unit	6	1/03
Acute 2 unit nurse	20%	-	-	-
Nurse assistant	5%	-	-	-

Second scenario:

1. The number of night shift nurses in Fast unit reduced to three.

2. the nurses in acute 2unit and CPR unit provide services together as a team with CPR priority.

- Average Number of Emergency Patients: 2,699 patients per month (3 increased)

In the second scenario, while preserving the first scenario, a team with acute 2 and CPR nurses was created with CPR priority. After extracting different scenarios and not seeing any tangible changes, we made a model with the above tow units' staffs as a team. As we see in Table 4, the efficiency for head nurse, CPR, Fast, Acute 1, and assistant nurses' was increased; but this increase was still unbalanced. Of course, along with this increase in the efficiency of nurses as a team, average number of Emergency Patients has also increased. In the second scenario, the waiting times due to an increase in overall capacity of patients have increased immensely.

Table 4: Human resource efficiency, and average waiting times and number of patients in waiting list in queues at emergency department in the second Scenario

Staff	Staff Efficiency (%)	The name of the waiting queue	Average waiting time in the current state (min)	The average number of people in the queue in the current state
Receptionist and Discharge officer	45% (No change)	The reception	0/16(0/01 increased)	0/01 (0/001 increased)
Triage nurse	25% (No change)	Triage	0/02(0/003 increased)	0/001 (No change)
Physician	93% (1% decreased)	1%Emergency Physician Visit	6/62 (1/05 increased)	0/4 (0/06 increased)
Head nurse	7% (3% increased)	Cardiopulmonary resuscitation (CPR)	0	0
CPR Unit Nurse	36% (31% increased)	Physician Visit in Fast unit	7/84 (1/1 increased)	1/26 (0/14 increased)
Fast unit nurse	18% (1% increased)	Physician Visit in Acute 1 unit	10/65 (0/5 increased)	4/18 (0/01 increased)
Acute 1 unit nurse	68% (4% decreased)	Physician Visit in Acute 2 unit	7/18 (1.18 increased)	1/32 (0/29 increased)
Acute 2 unit nurse	14% (6% decreased)	-	-	-
Nurse assistant	7% (2% increased)	-	-	-

Third scenario

1. The number of night shift nurses in Fast unit reduced to three.
2. The acute 2unit and CPR unit nurses work together as a team with CPR priority.
3. Nurses of the Acute 1 unit and Fast unit provide services as a team.

- Average number of emergency patients: 2726 patients per month (30 increased)

Regarding the optimal results with teamwork in the second scenario, it was more developed for the third scenario. So, while maintaining the first and second scenario, the nurses in the Acute 1 and Fast unites teamed up. Consequently, in this scenario, we observed an increase of 30 in the number of monthly patients. These new patients increased the waiting times relatively in different parts of the ED. We also saw changes in the efficiency of physicians and nurses,

which in some cases it has decreased and some has increased, and the efficiency of the members was more balanced than the initial state (Table 5).

Table 5: Human resource efficiency, and average waiting times and number of patients in waiting list in queues at emergency department in the third Scenario

Staff	Staff Efficiency (%)	The name of the waiting queue	Average waiting time in the current state (min)	The average number of people in the queue in the current state
Receptionist and Discharge officer	45% (No change)	The reception	0/15 (No change)	0/009
Triage nurse	25% (No change)	Triage	0/02 (0/01 increased)	0/001
Physician	95% (1% increased)	1%Emergency Physician Visit	9 (3/33 increased)	0/55 (0/21 increased)
Head nurse	8% (4% increased)	Cardiopulmonary resuscitation (CPR)	0	0
CPR Unit Nurse	3% (2% decreased)	Physician Visit in Fast unit	9/26 (2/52 increased)	1/43 (0/31 increased)
Fast unit nurse	34% (24% increased)	Physician Visit in Acute 1 unit	9/37(0/78 decreased)	4/14 (0/05 decreased)
Acute 1 unit nurse	34% (34% decreased)	Physician Visit in Acute 2 unit	9/54 (3/54 increased)	1/54 (0/51 increased)
Acute 2 unit nurse	13% (7% decreased)	-	-	-
Nurse assistant	8% (3% increased)	-	-	-

DISCUSSION

Considering the size, type and position of the hospital and its emergency department, the number of patient's arrivals, crowding in the emergency unit was expected. So, due to the large number of patients, different partitions and units were formed that such number of beds and areas are not know in any similar hospitals. Of course, this crowds of patients was a validation for correct selection of the study environment. The entrance rate followed up of the Poisson distribution, which is consistent with the results of the studies of Adeleke (2009), De Bruin (2007) and Kembe (2012).

For extraction of simulation scenarios, the most important barrier was its feasibility in the real world; so, after receiving the opinions of the relevant authorities, we found that there were limitations to team building in ED and could only consider those units as teams that have been introduced in 2th and 3th scenarios. Various studies have emphasis on the importance of teamwork and the need for awareness of the hierarchy of individuals in the emergency teams (Brock et al., 2013; Liu et al., 2012). For extracting simulation scenarios, variables have also been developed which include: 1-changing the number and composition of human resources, 2-finansial and physical facilities, and 3-some aspects of both aspects (Miller et al., 2004); of course, the second and third ways were not practicable in this study. Due to the importance of speed in emergency department, we needed to reduce patients waiting time and

simultaneously increase the staff's efficiency as much as possible and balance it with other colleagues.

Also, determining the minimum number of nurses required along with the patient's satisfaction from the service and also determining the number of nurses needed during each shift are the common goals of the studies which have been done in this field (Chick et al., 1940).

So, in the first scenario, while the patients waiting times didn't change, we saw an increase in the efficiency of other night shift nurses by reducing one nurse of night shift nurses. Jabali and Sinreich simulated different parts of a hospital with the development of a linear optimization model and reached the same conclusion with lower staffs had the same outcome with a reduction in Patients stay time (Sinreich and Jabali, 2007).

We know that reducing human resources, in terms of personnel costs, will be in benefit of the hospital; but this result does not necessarily indicate the addition of a nursing force in the night shift. We should note that it is possible at night suddenly a large number of accidental or traumatized patients arrive in the city center. At this time additional personnel are needed to reduce and minimizes the risk of a sudden increase in number of visits. Also due to long time shifts, personnel exhaustion is also possible and these forces can provide a safe alternative during their rest time.

In the second scenario, with the cooperation of nurses in the acute 2 unit and CPR unit in form of a team, we notice an increase in efficiency for head nurse, nurses, and nurse assistant, but there will be also changes in waiting times and another members' efficiency, which is not noticeable. As we notice in table 2, the lowest efficiency belongs to the head nurse that we could make changes in this scenario. In a study conducted at one general hospital emergency department, with the formation of nursing team, the quality of emergency services was significantly increased. These researchers recommended conducting similar researches for other parts of the hospital (Zeng et al., 2012).

It can be expected that participation and oversight of the head nurse in ED, and on team working, it is possible to increase attention and caring for the patient, which in turn affects the quality of service and improve patient safety. So that one of the important reasons for team working in hospital is to ensure patient safety. All these agents together that teamwork is associated with increased patients satisfaction (O'leary et al., 2012; Hull and Sevdalis, 2015). For these reasons, and because of the sensitive features of ED unites, it can be emphasized that ED authorities and head nurses should have full supervision on their teams in this department (Ajami, Ketabi and MahmoodAbadi, 2013).

In the third scenario, we see tow separately team work: 1. The acute 2 unit and CPR unit and 2. The acute 1 unit and Fast unit. The results of this collaboration have led to an increase in the number of patients of the emergency department. This result was similar to result of a study that interprofessional teamwork had the shortest length of stay and teamwork was a useful approach to reducing ED throughput times (Liu et al., 2018); also in another study physiotherapists' efficiency increased during their teamwork (Noorizadeh Dehkordi et al., 2014).

Also, in this scenario, some waiting times reduced, while others have had a slight increase. We know we cannot eliminate the waiting time and have all the desired needs at the same time, but we can move toward standards that are proportionally acceptable; as Chetouane and Duguay, who aimed to improve an emergency center and reduce waiting time by using Arena

software and modeling by variables of number of physicians and nurses in Canada; this study showed that by changing the control variables, the waiting time is close to their standard waiting time (Duguay and Chetouane, 2007).

Also, in this scenario, while increasing the efficiency of some staff, we see a decrease in some others compared to the initial conditions. Of course, we expect to have a balance among every team member's efficiency, because when all of members are involved in a common goal, each one tries for the relative work by him/her specialty and experience, so the work pressure is divided between them. In teamwork, compared to individual and traditional work, there is less professional pressure from work (Jackson and Mullarkey, 2000). It is necessary to know that the pressure from work is the response of individuals to work demands that are not suited to the individual's knowledge and ability (Dogaru and Donciu, 2014). In this study, along with changes in staff's efficiency, we notice that staff pressures distribute and balance in the form of teamwork.

Good communication between team members and patients and providing adequate explanations about care plans creates a sense of care in the patient (Khademian and Vizeshfar, 2008), so the role of patients as an important member of the health care teams is irrefutable (Martin and Finn, 2016) but in this study there was no possibility to import patients in emergency teams.

Clearly, by gathering a group of professionals, there is no desirable teamwork by itself, so it requires planning, training and practice (Clancy and Tornberg, 2007). Although staffs of the ED have trained in their disciplines, they have not professional training on how to engage and communicate in teams (Nguyen, Watson and Dominguez, 2016). On the other hand, each of these members has a culture, value, belief, attitude, and behaviors related to their profession and focuses on it (Hall, 2005). Also, the lack of clear definition of the tasks of individuals, poor management, incompatible communication, the existence of hierarchy in the sectors, lack of adequate knowledge, and inappropriate division of responsibilities are the major barriers to teamwork that need to be addressed to implement teamwork (Reader, Flin and Cuthbertson, 2007; Chakraborti et al., 2008).

CONCLUSION

Some management decisions are very costly and it is better to examine them in virtual environments before making decisions. Making teams and doing things based on these teams in order to achieve critical emergency indicators such as reducing and standardizing waiting times and increasing and balancing the work efficiency of personnel in sensitive healthcare settings is one of the hard and costly decisions. Also, the identification of barriers and facilitators of teamwork in different environments for specific use can provide favorable outcomes (Doyle, 2008). Hence, hospitals also need to have sufficient knowledge and appropriate model of their teamwork in ED.

Adding more native realities to simulation, as well as using other algorithms as the optimizer part, can be considered as suitable topics for the continuation of this research. interventions in the emergency based on teamwork and evaluation of results before and after the intervention can be useful, although it is advisable to use simulation tools before such interventions

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Footnotes

Ethical Approval: It should be noted that in the current study, there was no direct communication with patients and there were interactions with the department management; the researchers explained the study aims and methods to the hospital research unit and assured them about the accuracy and reliability of the reported results; however, the present study was approved by the ethical committee of Tehran University of Medical Sciences (code number: IR.TUMS.REC.1394.1287).

Informed Consent: Informed Consent was obtained for any ED staffs that participated in this study.

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