Simulation Models Of Emergency Department In Hospital

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Abstract:

This paper gives the Emergency Department (ED) room patient flow using a medium size hospital as a case-study model .The purpose of this paper was to determine the flow of patients through the Emergency case and Elective surgical to identify the data elements required to complete a quantitative analysis of waiting time issues. As this paper devote to building and validation of a simulation model using the discrete event simulation for modeling, analysis, and visualization. The basic model will be extended to simulate the effects of different operating strategies on patient waiting time in the ED.

Keywords : patients, Emergency Departments (ED), CPR (Cardio Pulmonary Resuscitation), Emergency Severity Index (ESI), Elective surgical.

محاكاة لنمذجة عمل قسم الطوارئ في المستشفيات

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الخلاصة:

أن الغرض من هذه الدراسة هي معرفة مدى تدفق المرضى إلى قسم الطوارئ بمستشفى متوسطة الحجم. وكما أن هذه الدراسة تهدف إلى معرفة الحالات الجراحية الطارئة والمستقرة من خلال تحديد البيانات الضرورية التي نحتاجها عن المريض لتحديد حالته ولتقليل مدة انتظاره. وقد اتبعنا في هذا البحث طريقة لنمذجة عمل المستشفى باستخدام نظام الأحداث المنفصلة ، لتحليل وتقييم عمل النظام. وأيضا قد تم تطبيق عدة ستراتيجيات لتقليل وقت انتظار المريض في قسم الطوارئ.

1. Introduction

Healthcare delivery can be very expensive and is often subject to delays that can be costly as well as dangerous to patient health. In our view both the problems of cost and delay might be addressed by devising superior approaches for evaluating the utilization of resources. The resources used in delivering health care include both equipment, such as beds, radiographic

imaging equipment, and operating suites and people, such as doctors and nurses. All of these resources are very costly. Accordingly these resources tend to be allocated sparingly in most health care settings. This can lead to a lack of sufficient resources that can be at least partly to blame for delays in delivering health care. Adding resources of only one type (e.g. more doctors) is rarely sufficient to reduce delays, however, as patient care typically requires the use of many types of additional resources (e.g. beds, nurses, and equipment)[1].

An Emergency Department (ED) is a medical treatment facility, specializing in acute care of patients who present without prior appointment, either by their own means or by ambulance. Due to the unplanned nature of patient attendance, the department must provide initial treatment for a broad spectrum of illnesses and injuries, some of which may be life-threatening and require immediate attention. The ED of a hospital is a complex unit where the fight between life and death is always a hair's breadth away, requiring a high degree of coordination among human and material elements. One of the common areas of concern in any ED is the reduction of waiting time or length of stay of patient[2]. In some cases, the patients may require treatment in a traditional ED room, but many can be discharged without using a room. The discharge process is followed by checkout which includes complete registration and insurance verification or payment is called (Elective case)[3].

The aim of this paper is simulation model designed to assess the effect on emergency department (ED) to reduce the interval of admitted patient departure from the ED and take the necessary care.

2. Related Works

In 2010 Yariv Marmor discussed the concept of the (ED) of a modern hospital is a highly complex system. Indeed, it gives rise to numerous managerial challenges from the Service Engineering area, spanning the full spectrum of operational, clinical and _financial perspectives, over varying horizons: operational few hours or days ahead, tactical - weeks or a few months ahead, or strategically - months to years ahead. Since realistic ED models are often intractable analytically, one resorts to simulation for an appropriate framework to address these challenges, which is what we do here[4].

In 2008 Erik M. W. Kolb discussed the concept of medical care issue in the United States and other developed nations. One major cause of ED crowding are holding patients waiting in the Emergency Room (ER) for inpatient unit admission where they block critical ED resources. With input data from a hospital in Massachusetts/ USA, we tested five patient buffer concepts which aim at relieving pressure of the ER. The buffers are also assumed to improve patient and staff satisfaction through their design tailored to needs in patient flow[5].

3. System Description

The ED of the hospital operates round the clock and receives an average of 58 patients daily. The ED is of thirty-bed capacity. The ED currently has twenty-eight nurses, fifteen physicians. There are two 12-hour shifts for physicians starting at 06:00 and 18:00 and three

shifts for nurses starting at 06:00, 13:00, and 18:00 in the ED of a governmental hospital. The patients are classified as per the Emergency Severity Index (ESI) standard in the triage. Triage codes assigned by triage nurses are critical to achieve a correct dispatch of patients (giving the right priority based on patient condition).

3.1 Acknowledging with the Proposal System

The proposal system is to simulate ED work in government hospital model. A regular patient enters the system at waiting room, picks a number and remains in the waiting area. When his number is called the patient is assessed by a triage nurse who screens for critical apparent symptoms (high blood pressure, fever, etc.) then the examination rooms are used to treat patients arriving from triage room. There are eight general examination rooms, four are equipped to deliver specific care such as orthopedics, hand surgery, infections treatment, and ophthalmology; otherwise If the patient's condition deteriorated will enter into a emergency room to take care of the required. On the other hand, if patient is required entered to Cardio Pulmonary Resuscitation (CPR), so that he can be resuscitated and he transferred to the emergency department for immediate care after stabilizing the patient's condition will be transferred to other lobby until improved discharge from the hospital or death. **Figure(1)** summarize the patient flow through the ED by a flow chart.

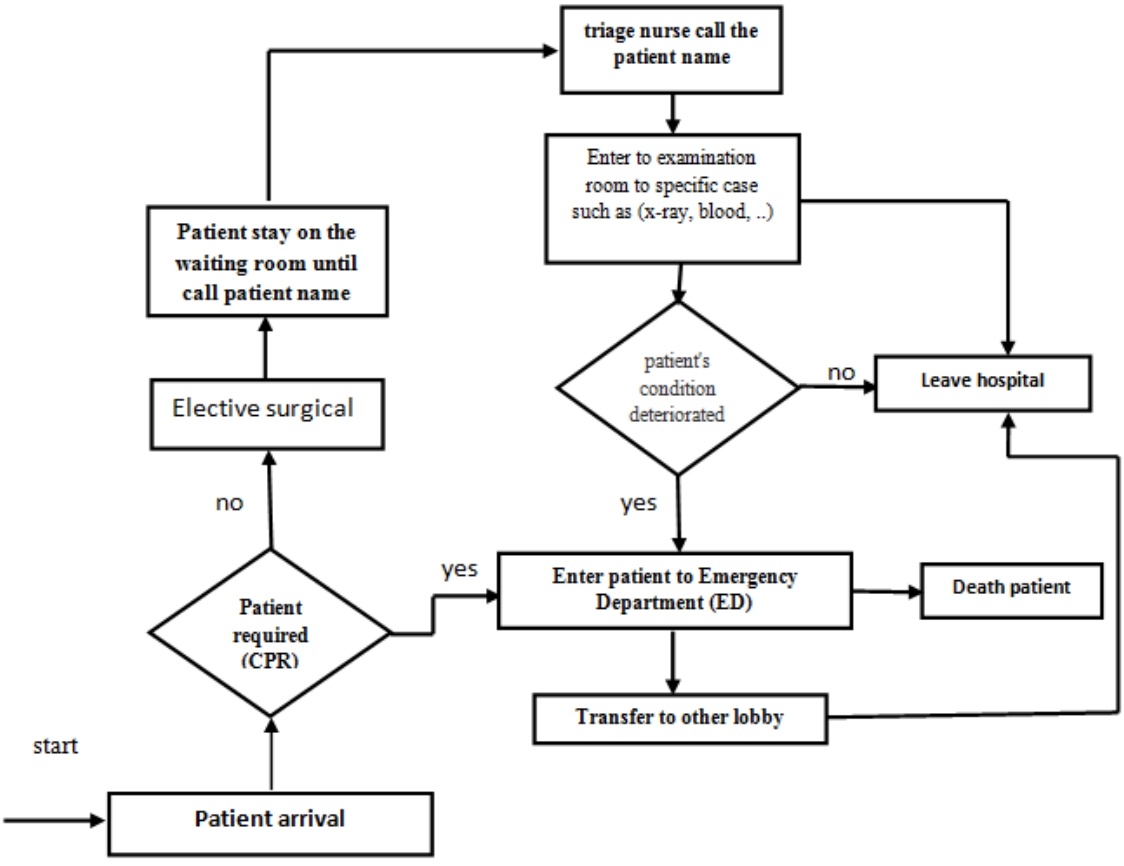

Fig .(1) Flow chart of proposed patient conditions

3.2 Methodology

The methodology of simulation models applied in the Emergency Department (ED) represent the patients flow to take care by the following steps:

1. Generate pseudo random number using function RND ( ).
2. Transform this number in to random variable exponentially distributed to represent the inter arrival time:

$$\text{Inter arrival} = -\frac{1}{l}\log(\text{random number})$$

3. Generate another pseudo random number
4. Transform this number to random variable exponentially distributed to represent the service time in examination room and in emerge time:

$$\text{service time} = -\frac{1}{m_1}\log(\text{random number})$$

$$\text{emerge time} = -\frac{1}{m_2}\log(\text{random number})$$

5. Calculate arrival time, waiting time, idle time and depart time

- arrival time (patients) =inter arrival time (previous patients)+ arrival time (current patients)
- Idle time= arrival time - depart time (if arrival>depart of previous patients)
- Wait time = depart time - arrival time (if depart > arrival of previous patients).
- Depart time= arrival time + service time + wait time +exam time + emerge time

4. Results and discussion.

By means of the created simulation model, with preliminary assigned for the two scenarios, each scenarios have number of patients the incoming flow, intensity of the incoming flow (arrival rate), if the patients is Elective condition then enter to the several phases until take care then leave from the hospital is simulated the operation of the system "Emergency Department ".

Scenario 1 – simulation of the "ED" as Elective Case model having Poisson incoming flow about the patients with an average inter-arrival time**. Figure (2)** shows a sample of the program tabular results to simulation model of elective surgical when $l = 0.6 \; and \; m = 0.3$, and not required to count the time in emergency department, the results are display as graphical scheme that represent the leave time in **Figure(3).**

Patient No	interarrTime	arrivaltime	TriageName	waitRoom	ExamRoom	leave time	idel time
1	6.3	6.3	0.3	0	2	8.6	6.3
2	0.6	6.9	2.2	1.7	2.3	13.1	0
3	1.7	8.6	4.4	4.5	3	20.5	0
4	2.4	11	9.3	9.5	0.1	29.9	0
5	1.7	12.7	6.2	17.2	2.4	38.5	0
6	2.3	15	2	23.5	1.5	42	0
7	0.1	15.1	2.3	26.9	1.4	45.7	0
8	3.7	18.8	2.6	26.9	0.8	49.1	0
9	0.9	19.7	13.3	29.4	0.6	63	0
10	4.3	24	3.7	39	7.5	74.2	0
11	13.9	37.9	1.4	36.3	2.1	77.7	0
12	0.3	38.2	5.5	39.5	8.3	91.5	0

Fig .(2) Tabular results of Elective Case

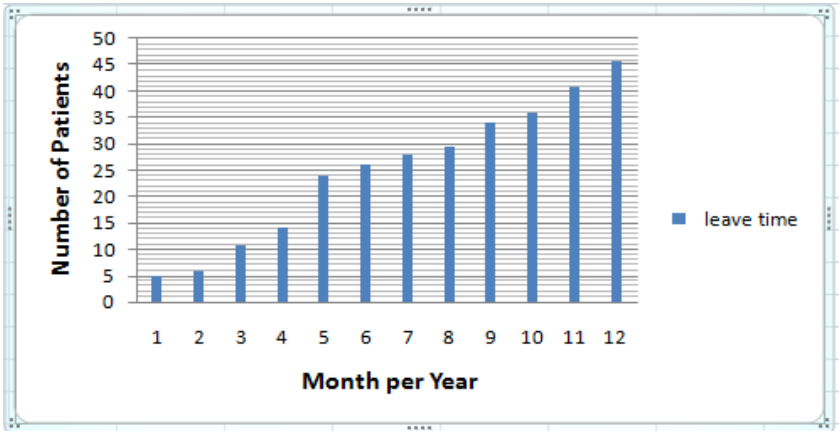

Fig .(3) graphical results of Elective Case model

Scenario 2 – simulation of the system "ED" as Elective Case with Emergency model having Poisson incoming flow with an average inter-arrival time of the patient flow and emergency time as exponential distributed. **Figure (4)** shows a sample of the program tabular results to simulation model, when $l = 0.4$, $m = 0.02, m_1 = 0.3, m_2 = 0.09$. If the patient's condition worsened, it is necessary to transfer to the emergency room therefore required to count time in the emergency department and display the results of leave time as graphical scheme in **Figure(5).** In the tabular results represent the elective surgical by value of (1) but if the patient required transfer to the ED represent by value (0).

Patient No	interarrTime	arrivaltime	TriageName	waitRoom	ExamRoom	electivesurg	EmergnTime	leave time	idel time
1	2	2	0.9	0	1.4	1	0	4.3	2
2	0.3	2.3	1.1	2	4.4	0	15.5	25.3	0
3	0.2	2.5	0.8	22.8	0.2	0	4.9	31.2	0
4	0.2	2.7	9.6	28.5	5.1	0	0.3	46.2	0
5	1.1	3.8	0.9	42.4	2.6	1	0	49.7	0
6	1.3	5.1	4	44.6	2.2	1	0	55.9	0
7	2.2	7.3	4.3	48.6	1	1	0	61.2	0
8	0.9	8.2	0	53	7.4	1	0	68.6	0
9	0.6	8.8	0.1	59.8	3.1	1	0	71.8	0
10	3.7	12.5	0	59.3	20.8	1	0	92.6	0
11	0.9	13.4	7.7	79.2	1.1	1	0	101.4	0
12	2.1	15.5	10.3	85.9	4.8	1	0	116.5	0

Fig .(4)Tabular results of Elective Case with Emergency model

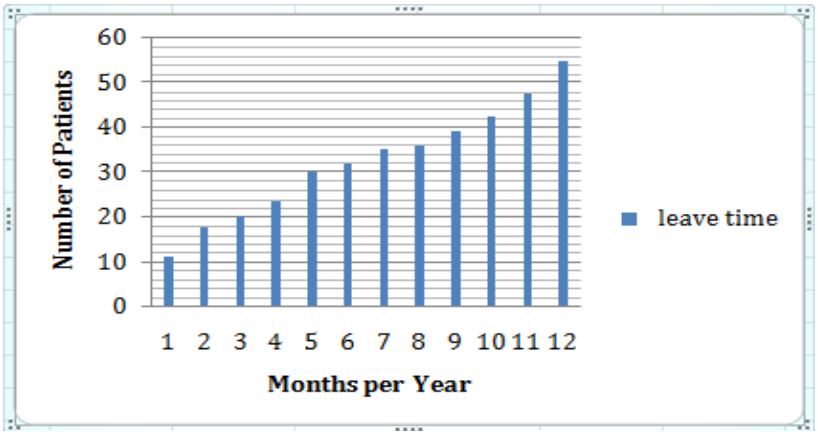

Fig .(5) graphical results of Elective Case with Emergency model

Scenario 3 – simulation of the system "ED" as emergency model having Poisson incoming flow with an average inter-arrival time of patients as exponential distributed. Figure (6) shows a sample of the program tabular results to simulation model, when $l = 0.3$ *and* $m_1 = 0.6$. Display the results of leave time as graphical scheme in Figure (7). In the tabular results represent the emergency case by value of (1) but if the patient death represent by value (0).

PatientNo.	interarrTime	arrivaltime	Emergntime	LengthofStay	EmergnCase	Service2	leavetime	idel time
1	2.1	2.1	4	0	1	1.3	7.4	2.1
2	7.1	9.2	0.9	0	1	1	11.1	1.8
3	0.6	9.8	10.3	1.3	1	4.4	25.8	0
4	0.2	10	0.8	15.8	0	0	26.6	0
5	0.1	10.1	0.5	16.5	0	0	27.1	0
6	0.1	10.2	3.4	16.9	0	0	30.5	0
7	0.4	10.6	9.8	19.9	0	0	40.3	0
8	1.3	11.9	4	28.4	1	2.4	46.7	0
9	0.7	12.6	4.4	34.1	1	6.4	57.5	0
10	0.3	12.9	0.6	44.6	0	0	58.1	0
11	0.1	13	0.3	45.1	0	0	58.4	0
12	0.6	13.6	0.1	44.8	1	7.1	65.6	0

Fig. (6)Tabular results Emergency model

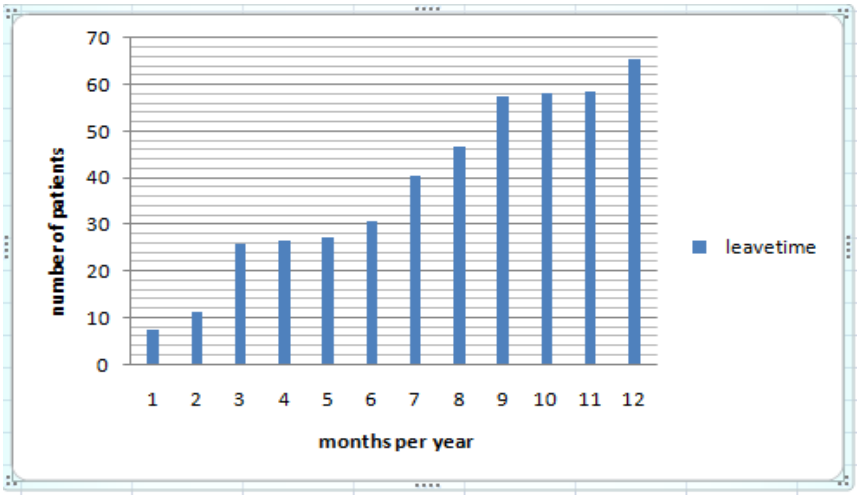

Fig. (7) graphical results of Emergency model

5. Conclusions:

The simulation model gives the patients flow through an illustrative emergency department in hospital by a following special features:

- The queuing models enhance a new dimension in computer simulations which take to consideration the waiting time reduced. Via applying several models queuing , the minimum waiting time will obtained.

- The priority discipline is measure of urgency or importance, when the patients arrival to hospital by ambulance before other patients because it's urgent, therefore waiting time in this state is smaller than without.
- The elective case with emergency model is measuring service time ; the average of depart from (**92.4**) is greater than average depart from case of elective without emergency **(76.2**).
- ED represent an important department in hospital because the patients required a special health to access a best case without any delay.

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