A Discrete Event Simulation Model for the Management of Patients Flow in Healthcare Emergency Department

Modibbo U. M.[1], Okolo A.[2]

Research Scholar, Department of Statistics and Operations Research, Aligarh Muslim University, 202002, Aligarh, UP India

Abstract: ***This paper demonstrates the use of discrete event simulation as applicable in healthcare industry. It investigated the congestion in Emergency Department(ED) of Federal Medical Centre, Yola-Nigeria. Patient flow processes were modeled using ARENA simulation software. Also patients waiting and service times were simulated. The simulation result revealed that on average, Patients spent 22 minutes waiting for consultation and 38 minutes for receiving services daily in the ED, as compared to the actual data which is approximately 32 minutes and 67 minutes respectively. Based on the result obtained from the simulation model developed, it is shown that there is a long waiting period for a patient to gain consultation even if an appointment system is applied. The most prevalent issues that affect the ED of FMC Yola are bed availability and the need to divert patient traffic when the ED is full.***

Keywords: Discrete Event; Healthcare, Emergency Department; Simulation; *ARENA* version 14.70.00;

1. Introduction

Health is one of the most pressing central issues for people all over the world. Hospitals, which are core elements of healthcare systems are made up of independently distributed complex care units, such as, cardiology, emergency, gastroenterology, neurology and X-ray departments (Decker and Li, 1998). The Emergency Department (ED) is a key component of healthcare system and it is responsible for managing the large influx of patients who need urgent attention. This unit is opened at all hours of the day including public holidays.

A visit to Federal Medical Centre (FMC) Yola, Nigeria reveals that the ED is very congested with patients having serious injuries and ailments at any given point in time. Before a doctor attends to one patient, another one is rushed-in continuously for 24 hours daily with patients spending longer time in the process due to limited resources thereby creating a crowed. Waiting times are too long and patients have to spend too much time in the process until they are discharged. These problems have continue to present an extreme challenge to healthcare managers, and have created dissatisfaction among patients and personnel.

According to Toni (2006), the basic objective of ED management is to provide affordable healthcare of optimal quality. People expect to be diagnosed as soon as possible, without any unnecessary waiting, and be treated with good care through the whole process.

Furthermore, in an attempt to manage patient flow in hospitals, Modibbo and Hafisu (2018) model the Length of Stay (LoS) of patient using poison regression model. They asserted that problems such as too long waiting times of patients, ineffective resource allocation and too low resource utilization remain the major concern of management. Hence there is the need to model the patient's process flow so as to proffer an optimal approximate solution to the situation.

Cabrera (2010) reported that resource planning of an ED is a complex activity, since it is not linear and varies depending on time, week-day and season. Lin *et at.* (2013) used the queuing model to estimate the average waiting time for patients and the resources needed in unscheduled and inpatient care. Lowery (1996) documented that discrete event simulation can be used to develop a model to observe the dynamic behavior of a system. The ability to simulate special situation such as seasonal increase in ED, demand processes can be useful for efficient use of resources (Ahmed and Alkamis, 2009).

2. Material and Methods

In this study, resources such as doctors, nurses and technicians were considered as decision variables in managing the patients' process. Data on the number of doctors, nurses, shifting roaster, beds, stretchers, conches, mode of patient's arrival either by walk-in or ambulatory, patient's arrival time so as to deduce the inter-arrival rate, type of patient's emergency case whether accident, disaster, medical or gynecology, patient's waiting duration at each waiting point in the process, patient's gender, age group and education level were collected for a period of sixty three days in the ED of FMC, Yola, Nigeria. Patients were observed 24 hours a day and information recorded on a data capture form. Data was processed using Arena Software packages. Within the period, six hundred and ninety three (693) patients with diverse emergency cases visited the emergency Department.

3. Patients Flow in the Emergency Department

The following is a process flow of patients into the emergency department:

a) Arrive by walk in; if no immediate care is required, they proceed to the registration place, whereas those who require immediate attention and those who arrive by ambulance are directly sent to the treatment area.

b) Patients wait if the registration staff is busy and thus, go to a triage area after registration where the triage nurses are, if the nurses are busy, patients have to wait again, but in another area where their conditions are evaluated and a priority level is assigned.
c) Then, patients wait for diagnosis at a treatment room with a doctor;
d) Finally, patients could be admitted into the ward or discharged.

This process flow is shown in fig. 1.

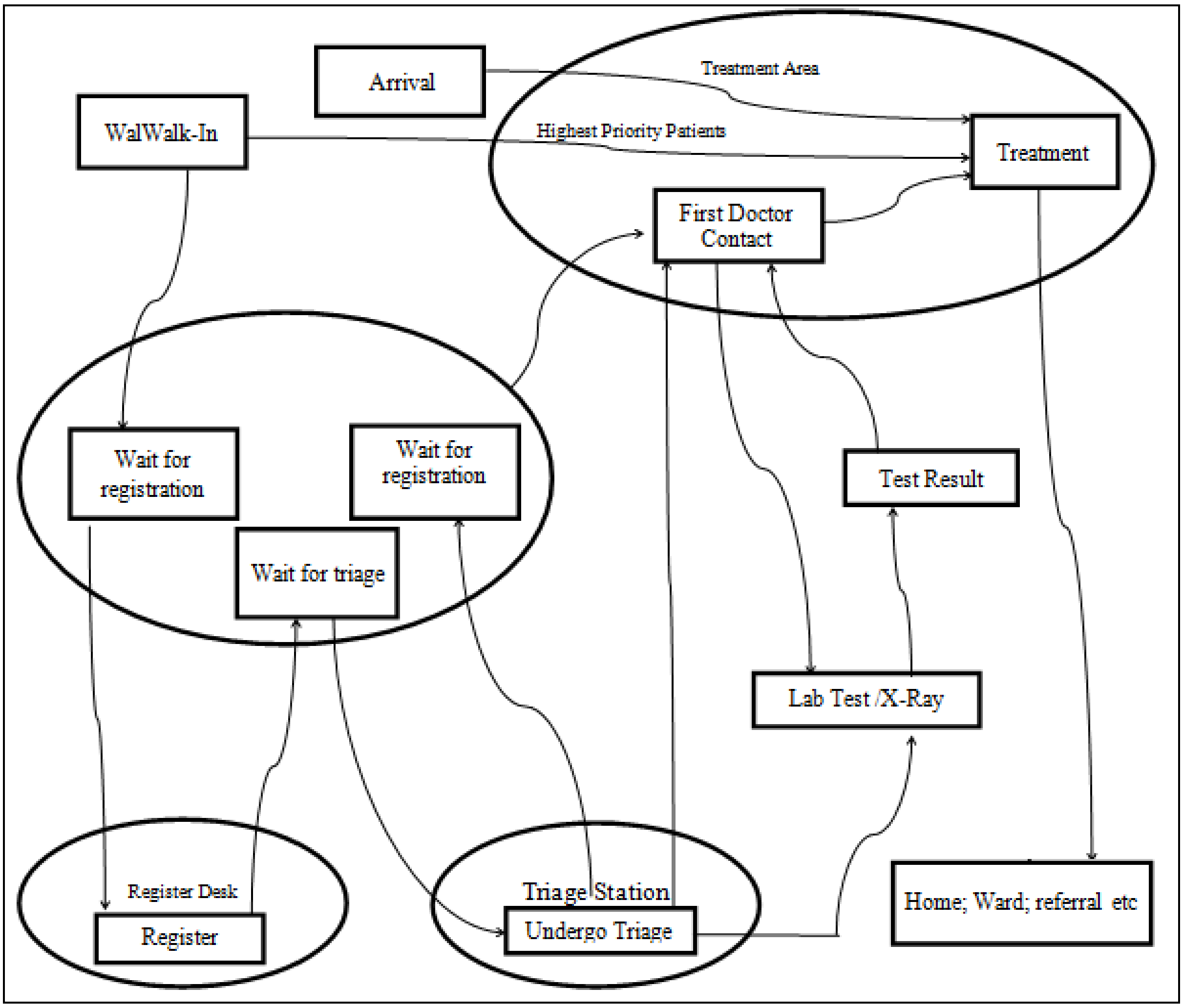

Figure 1: A Conceptual Model of Patient's Process Flow in ED of FMC, Yola, Nigeria

4. Modeling the Patient Flow Process

A modular approach that is contained in the *Arena* Basic Process Panel (Figure 2) was adopted in the model development. The model is made up of the following Modules: create module which contain the patient arrival, decide modules that test patient's level of acuity and X-ray requirement, process modules which contains the patient waiting, registration, triaging, doctor's assessment and treatment, record module that count the entity passage and finally the disposed module which discharge the patient from the ED. Model output consist of waiting durations and resource utilization.

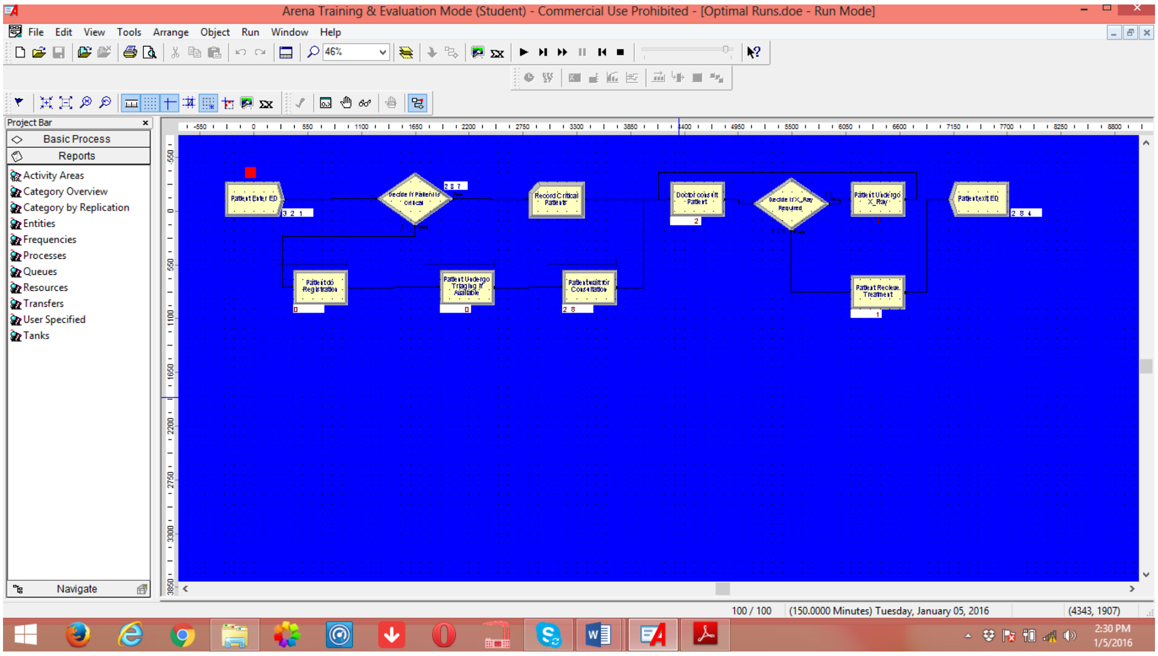

Figure 2: Emergency Department Arena Model

The simulation model was performed for a period of one hundred and fifty minutes and the process replicated 100 times. The system was always initialized between replications with a warm up period of 0.0 minutes since it starts from an empty status. Comparison of the simulated output with the actual data was made for model validation, using a confidence interval of 95% on the expected value of the corresponding performance measures (Table 1).

A graphical presentation of the actual and simulated waiting and service times are shown in Figure 3 and 4 respectively.

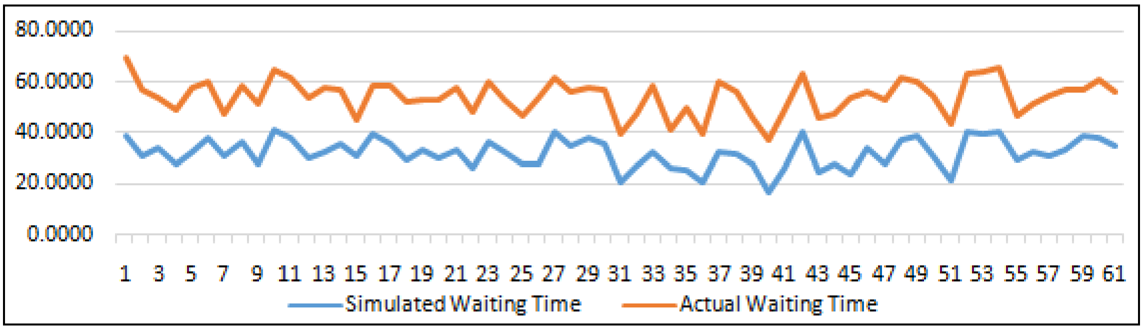

Figure 3: Actual and Simulated Waiting Time

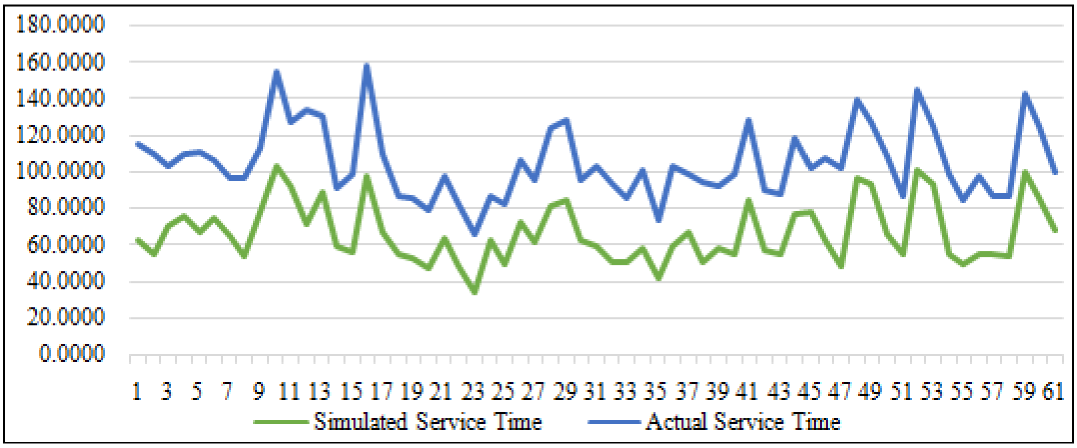

Figure 4: Actual and Simulated Service Time

5. Results and Discussion

The simulated maximum average waiting and service times are 22.1854 and 38.3202 minutes per patient respectively as shown in Table 1. This means that, for the simulated data, each patient has to wait for approximately 22 minutes in the process before seeing the consultant and another 38 minutes for receiving services daily in the ED. For the actual data, the average waiting and service times are 32 and 67 minutes respectively. This improvement in waiting and service times for the simulated data is as a result of additional consultant in the simulation.

Table 1: Comparison between Actual and Simulated Average Daily Waiting and Service Times for ED Patients for sixty three Days at F.M.C. Yola

Days	Actual daily average waiting time (Minutes)	Simulated daily average waiting time (Minutes)	Actual daily average service time (Minutes)	Simulated daily average service time (Minutes)
1	38.8846	30.5200	63.4500	51.7536
2	31.0833	26.0800	55.5000	54.1652
3	34.0000	20.0500	70.2857	32.3381
4	27.8182	21.1800	75.9091	33.1867
5	32.5294	25.3300	67.0000	43.5894
6	37.8800	22.2700	74.5714	32.0434
7	30.8182	16.7900	65.0909	31.3523
8	36.1905	22.0500	54.2381	41.6343
9	27.7500	23.5800	77.9000	35.0727
10	40.9375	23.6200	103.3125	51.6152
11	37.5714	23.6200	92.7619	34.2584
12	30.2143	23.1200	72.0714	61.5895
13	32.0800	25.7600	89.6429	40.2656
14	35.6000	21.4300	59.4000	31.3566
15	31.0000	13.8900	56.2200	42.0762
16	39.1100	19.7100	97.4400	60.2311
17	35.1250	23.3400	67.2500	42.1848
18	29.0700	23.0800	55.5000	31.1272
19	33.0400	20.2500	53.5556	31.3348
20	30.0000	23.3000	47.1429	31.5330
21	33.3300	24.1700	64.3300	33.6237
22	26.4300	22.1500	48.6364	33.8518
23	36.0000	23.7300	34.5600	31.0865
24	32.2200	20.6700	63.2200	23.1885
25	27.3300	19.1900	49.3300	33.1167
26	27.8300	25.5300	72.8330	33.7399
27	40.5000	21.3300	61.8300	33.6069
28	34.8600	20.9200	82.0000	41.5543
29	38.1100	19.6800	85.1100	43.0542
30	35.6250	21.4300	62.5000	32.6173
31	20.9000	18.8900	59.7000	42.9182
32	26.6300	20.6300	50.6700	42.3167
33	32.5600	25.8300	50.8900	35.0112
34	25.8900	15.6100	58.5600	42.1749
35	25.6700	24.3000	42.1700	31.4425
36	20.9000	19.1000	59.7000	42.9748
37	32.6400	27.3300	66.9100	32.0837
38	31.9300	24.3800	51.3600	42.3375
39	27.9500	17.9600	59.0900	32.8304
40	16.8300	20.4300	55.8300	43.2139
41	26.1300	22.7000	85.2500	42.5210
42	40.0000	22.9600	57.3300	32.4958
43	24.2500	21.4500	54.9200	32.6025
44	27.8000	19.9900	77.2000	41.5098
45	23.8800	29.7800	78.5000	23.1805
46	33.8000	22.4600	63.4000	43.6320
47	28.1000	24.6600	48.6000	53.6165
48	37.1200	24.2800	97.0000	42.0809
49	38.8600	21.2300	93.0000	33.4567
50	31.1100	23.1000	66.6800	41.1653
51	21.8800	21.8200	55.1200	31.2236
52	40.3800	22.6800	101.6300	42.9932
53	39.5700	24.0800	93.5000	30.8693
54	40.0000	25.1500	55.1000	43.0903
55	28.9000	17.7300	49.6700	34.2455
56	32.2000	18.8400	55.7100	42.0741
57	30.8300	23.9700	55.3300	31.2302
58	33.4100	23.4000	54.3100	31.8379
59	38.7800	18.3700	100.1100	42.1939
60	37.5000	23.2500	85.3800	39.0000
61	34.7600	21.6800	68.1100	31.1949
62	39.6700	21.8900	63.3300	36.1047
63	40.3800	19.9800	102.3800	52.4003
Total	**2034.1474**	**1397.6800**	**4239.0318**	**2414.1706**
Maximum Average	**32.2881**	**22.1854**	**67.2862**	**38.3202**

References

[1] Ahmed, M.A and Alkhamis, T.M. (2009), Simulation optimization for an emergency department healthcare unit in Kuwait. *European Journal of Operational Research,* 198(3):936-942.

[2] Cabrera, E. C. F. (2010), Agent based simulation to optimize emergency departments. Master's thesis, UniversitatAutonoma de Barcelona, July 2010.

[3] Decker, K. and Li, J.(1998), coordinated hospital patient scheduling, in ICMAS '98: proceedings of the 3rd international conference on multi-Agent systems, IEEE computer society, Washington DC, USA, P.104

[4] Lin D, Patrick J, Labeau F. Estimating the waiting time of multi-priority emergency patients with downstream blocking. *Healthcare ManagSci*(Published online May 2013).

[5] Lowery, J. (1996), Design of Hospital Admissions Scheduling System Using Simulation. In Proceedings of the 1996 Winter Simulation Conference, Coronado, California, United States, pp. 1199-1204.

[6] Modibbo, U. M and Hafisu, R. (2018a), "Modeling Patient's Length of Stay Using Poisson Regression in Hospital Emergency Department". *International Journal of Science and Research (IJSR) Volume 7 Issue 7. Pp.1033-1039.* DOI: 10.21275/ART20183959

[7] Toni, R. (2006), Simulation Model for improving the operation of the Emergency Department of Special Healthcare. *Proceedings of the 2006 Winter Simulation Conference pp. 453-458*