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An Evaluation of Emergency Department Treatment Process

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Abstract: This study presents the simulation model to evaluate the treatment process of Emergency Department (ED). The two objectives are mainly considered which are by identifying various procedures in ED of a general hospital as well as to evaluate resource utilization that may lead to the bottleneck. ED is known as the frontline of service provider that opens 24 h per day to serve patients that comes to their door. Regardless with the increasing of patient's number, hospital organisations are keen to meet the demands in ED where the demand of services provided exceeds their ability to serve patients in an appropriate time frame. The use of Discrete Event Simulation (DES) Model allows hospital administrator to understand the treatment process and detected the bottlenecks area in the process. Theory of Constraints (TOC) is also used to identify the constraints in the areas examined in ED. The results from the scenarios experimentation showed that comparison with 20% increase of patients to triage zones affects the different treatment time procedures.

Key words: Waiting time, bottlenecks, simulation, emergency department, patient flow, TOC

INTRODUCTION

Based on Malaysia Healthcare System, there are two highly organised sectors known as government healthcare and private healthcare under Ministry of Health. Highlighted under the 10th Malaysia Plan (2011-2015), healthcare industry is among the 12 National Key Economic Areas (NKEA) that been focusing to bringing both of the sectors in a more organised and coherent manner. In addition, healthcare industry in Malaysia has become a powerful engine of economic growth. Despite of it, healthcare units either in private or government sector face challenges on imbalance between limited resources and increasing demands from the community. As a result, hospital administrators and policy makers are becoming more and more concerned with patients waiting time because it is a measure of organisational efficiency (Pillay *et al*., 2011).

Emergency Department Overcrowding (EDOC) has been longstanding problem not only in Malaysia but worldwide. According to Niu *et al*. (2013), the researchers defined EDOC as the imbalance between limited resources and increasing demands placed on Emergency Department (ED). Another reason of EDOC is the poor patient flow because of the inefficient treatment process in ED (Lantz and Rosen, 2016). A lot of researches were conducted to evaluate the patient flow to find the bottlenecks and capacity constraints in ED (Ahmad *et al*., 2012; Wang *et al*., 2012; Zhao *et al*., 2015). In order to optimize the patient's flow, some methods such as forecasting, optimization and matching of demand and capacity are proposed for improvement in ED operation (Devaraj *et al*., 2013; Zhao *et al*., 2015).

As the main point of entry into hospitals and accounts more than half of admission to hospital, ED operation is known as complex system. Patient's flow in ED is affected by many factors and may experience many variations and one of the factors is the treatment process. Although, there are different research were conducted in this field, there is still a lacuna in general theory and the existing models. Most of the improvement was done using the intuition and expert judgement (Pillay *et al*., 2011; Wang *et al*., 2012).

Modelling patient flow in ED system requires an approach that can portray the integrated components. As ED consists of three main components which are people, process and equipment (Ahmad *et al*., 2012), Discrete Event Simulation (DES) is used to described patient flows and treatment process of ED. In addition, according to Brailsford *et al*. (2007, 2010), the researchers stated that simulation were used in healthcare system as decision making for improvement in care process, to represent dynamics characteristics and also to evaluate the workflow existing. Theory of constraints proposed by

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Goldratt was used as a scientific process for generic problem solving and identifying the bottlenecks in the system. TOC is used in this research in early stage to identifying the bottleneck area in the treatment process while DES is used to model the examined area.

Bottlenecks that affected ED overcrowding have to be detected to reduce variation. Due to this fact, a simulation model is built to understand ED treatment process that affected patient's flow. TOC was used to identify areas examined in the ED treatment process. Model built using simulation provides the efficient search for priority areas of the ED improvement.

MATERIALS AND METHODS

System model description: The ED understudy receives an average of 450 patients within 24 h every day. From Fig. 1, the graph shows the number arrival of patients for 3 years period. Meanwhile Fig. 2 shows ED treatment process in a general hospital consisting of three main procedures of operations (Fig. 3):

- Acuity level identification (triage system)
- Distribution
- Receiving treatment

The process flow begins with arrival of patients either by ambulance or walk-in patients. In the stage of acuity level identification (triage system), information of patients is gathered by a receptionist. At the same time, the patients will visually triage (quick triage) by a triage nurse or assistant health officer that in charge at registration counter to decide on their acuity levels based

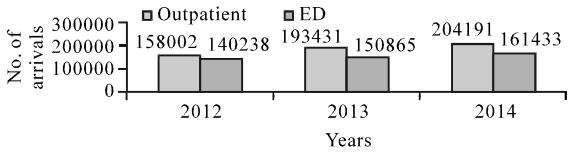

Fig. 1: Arrival number of patients to ED from 2012-2014 (Department of Medical Records, Selangor General Hospital)

Fig. 2: Patient's process flow for treatment

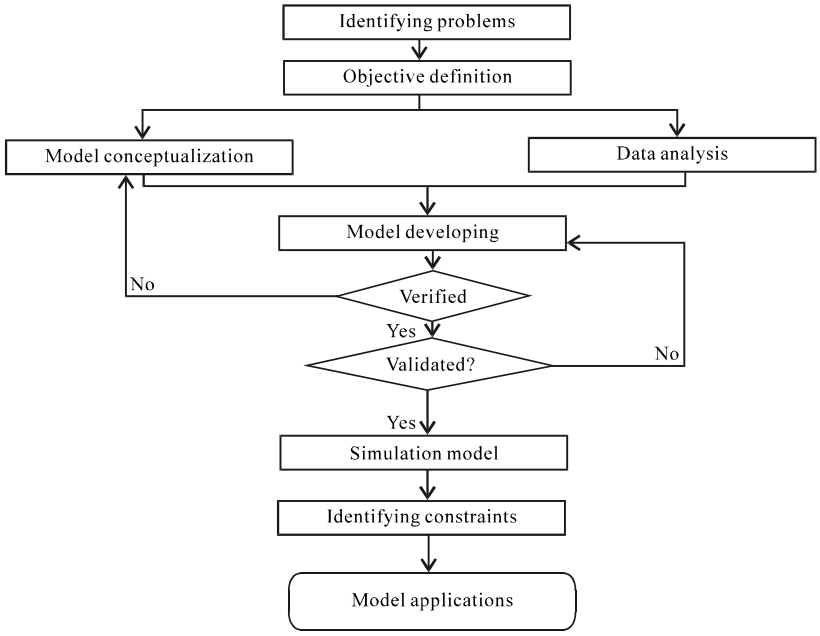

Fig. 3: General simulation steps (Sargent, 2013)

on scale in MATC (Malaysian Triage Category). Next, patients will go through simple test (blood test) before been assigned to MATC levels known as critical (red zone), semi-critical (yellow zone) and non-critical (green zone).

Green zone is the least acuity level and red zone means real emergency which is threatening patient's life. The patient who needs the emergency treatment will be referred directly to resuscitation area known as red zone. Patients who needs immediately treatments but without life threatening will be sent to treatment area (yellow zone). Non-critical patients will be located at the minor treatment area where patients can wait for treatments. The EDOC most likely happens at green zone and patients need to wait up to 2 h waiting for availability of doctors (Pillay *et al*., 2011). The delays of doctor to patients contact (waiting to be seen) depend on their acuity level based on Malaysian Triage Category (MATC). Doctors will decide, if the patients need to be up-triage for further test such as clinical lab test or X-rays. The results obtained will be reviewed by doctors and the decisions will be made upon the results. Some patients may be locating under observation's ward before being admitted to the specialty ward or being release for discharged.

Model development: There is several structured approach to conduct simulation study. A flowchart of simulation modelling is shown in Fig. 3. The conceptual model is abstracted (or generated) from the real ED operation. The ED model is built using simulation software called Arena. The model is first verified and validated before the application. Verification process makes sure that the model operation portrays the flowchart of the conceptual model (Sargent, 2013). The ED logic model was shown and verified by the ED administrators. The validation ensures that the simulation model represents the reality (Kleijnen and Sargent, 2000). For validation confirmation, waiting to be seen and length of stay were used as output measures. The 95% confidence interval is used to evaluate model output and 12 replications of model running are performed. Then, we compared the output measures with the historical data given by ED administrators.

RESULTS AND DISCUSSION

The data-driven from simulation tool developed from managerial and operational concerns. In particular, ED administrators was interested want to know how many staffs should be dedicated to different treatment areas and how ED system would perform with arising in patient volumes using current resources. As a benchmark, base scenario was simulated in which resources and patient volumes were set at current levels. Human resource were subject to schedules which varied by the time of day. Results from the DES Model reveal that average of 3230 patients visit the ED per week which is indication of high variability patient volume to ED. Theory of Constraints (TOC) was first used to identify the constraints in the ED treatments and process. Prior to the output results from simulation, we first compare the base case using 2014 data, against performance metrics within the emergency department for the same period. The results of this comparison are found in Table 1.

From the discussion with ED administrators, we used what, if analysis to tested three scenario by increase 20% the patient's attendances to the ED. The average waiting time to be seen by the doctors is presented as average treatment time for both green zone and yellow zone and also considered the up-triage process. As expected, for Scenario 1, by increase number of attendances to ED to 20%, average treatment time and average length of stay for non-critical (green zone) patients is increase more than 50%. From the scenario, it also shows that average waiting time for secondary triage that give impact to the average waiting time to be seen also.

In Scenario 2, due to the number of attendance increase by 20%, there is an obvious difference compare to the green zone patients. Both of the average waiting time for triage (bedside registration) and average waiting time for treatment increase along with the average length of stay in yellow zne. From the both Scenario 1 and 2 show the higher comparison values compared to the base model.

For Scenario 3 with the increase of 20% number of patients clearly shows that when the numbers of patients in red zone increase, the average waiting time for both

Table 1: Comparison of wait times, treatment times and length of stay

		Scenario 1 (increase triaged green zone by 20%)		Scenario 2 (increase triaged yellow zone by 20%)		Scenario 3 (increase triaged red zone by 20%)	
Variables	Base models	Mean	CI	Mean	CI	Mean	CI
Mean wait time for primary triaged green (min)	2.5	3.30	(3.07-3.93)	3.72	(3.54-.20)	4.13	(3.82-4.95)
Mean wait time for secondary triaged green (min)	20.20	34.92	(24.76-45.62)	41.05	(30.54-50.65)	47.14	(40.64-54.92)
Mean treatment time for triaged green (min)	58.16	70.91	(65.07-73.87)	71.12	(68.45-80.34)	71.64.	(60.86-81.12)
Average length of stay in green zone (min)	110.59	116.65	(112.13-124.11)	133.24	(113.52-150.76)	155.48	(126.28-184.56)
Mean wait time for triaged yellow (min)	4.5	5.45	(4.25-6.75)	8.76	(4.84-15.45)	9.28	(5.64-15.86)
Mean treatment time for triaged yellow (min)	113.26	132.12	(113.51-150.73)	110.78	(98.78-128.36)	136.78	(112.51-148.37)
Average length of stay in yellow zone (min)	136.33	158.38	(126.43-183.65)	138.25	(126.38-154.44)	154.46	(122.89-184.96)

Table 2: Resource utilization in ED

Variables	Original simulated output (%)	Scenario 1 (increase triaged green zone by 20%)	Scenario 2 (increase triaged yellow zone by 20%)	Scenario 3 (increase triaged red zone by 20%)
Doctor	56	62	66	68
Medical assistant	71	73	77	75
Nurse	45	48	51	53
Secondary triage waiting area	70	78	76	77

green and yellow zone is increase along with their average length of stay in ED by more than 130%. This happened due to the factors that the doctors and others staffs need to treat severe zone and do resuscitation process that took about more than half an hour per session.

With regards to output results, Table 2 represents for resource utilization, medical assistance score the highest utilization exceeds of 70%. The higher in utilization is proved the administration's claim that they do not have sufficient medical assistant and they usually the busiest resources to assist the doctors in treatment process and also for others ED operation. Meanwhile, for the secondary triage phase, the waiting area becomes busier which was 70% from the normal time when the number of green zone triage and up-triage to yellow zone is increased.

CONCLUSION

This study discussed on simulation study of an emergency department in general hospital. The developed model enhances administration understanding of treatment process that leads to EDOC by imbalance limited resources to the demands for healthcare services. The model is used to identify the bottleneck in the ED system by maintaining the existing resource capacity. The bottleneck detection of ED operations provides a direction for improvement of healthcare system. Using the proposed simulation model, ED administrators can have better understanding on the patient experience, process performances and also the staffing functions and relationships. The result shows that, by increase the number of patients to ED, the treatment process time and the staff utilization will also increase. The increment in the staff utilization leads to the heavy workload and became as the major influence on patient waiting time and also interrupts the treatment process in ED.

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