Simulation Application In Healthcare: A Case Study Of Outpatient Clinic In An Hospital, Hochiminh City

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Abstract. Vietnam's hospitals are facing overcrowding of patients in outpatient treatment. That caused many problems for the patient because it takes a long time for waiting; besides that, staffs and facilities are required to operate intensively in outpatient clinics to mitigate with these problems. To cope with the problem, a discrete event simulation is applied which focus on the process of healthcare, resource allocation, and patient flow to solve the local congestion at the hospital. A comprehensive model was built by using data from the hospital and real-time research. It is believed that simulation is an effective problem-solving tool for outpatient clinic, however, this method can be improved in the future. We hope that this model can be applied to reality if it will be rearranged reasonability so as to deploy whole potential of the hospital.

Keywords: *Simulation, Healthcare system, Patient flow, Outpatient clinic.*

1. INTRODUCTION

Health care is increasingly taken seriously, which makes the hospital management system plays an important role in improving the quality and efficiency in health care. Based on these studies and reports, the various aspects of the health care process has been thoroughly studied and analyzed in detail as to improve the flow of the process of health care, besides the scheduling and planning for clinics, emergency rooms, operating rooms, and machinery equipment, as well as identify the factors affecting the patient's waiting time in the clinic.

According to the General Statistics Office, Vietnam has now more than 1180 hospitals with approximate 200.000 beds. while Vietnam's population is over 90 million. That has led to an overload in the health care of patients.

Table 1 The statistics hospital in Vietnam in 2013

No.	Category of hospital	Number of hospital	Number of beds
1	Hospitals under the Ministry	39	22.110
2	Province Hospital	382	98.375
3	District Hospital	561	60.628
4	Specialized hospital	48	8.287
5	Private Hospital	150	9.611
TOTAL		***1180***	***199.011***

Situation showed that the majority of major hospitals in Vietnam are in overcrowding. Meanwhile, the cost of health care for Vietnam is 53.5 USD /person, lower than many countries in the region such as Thailand (136.5 USD /person) and Malaysia (307.2 USD /person) and the rate of doctors in

people's 8 doctors /10,000 persons. That proves, the healthcare system in Vietnam is in a state of lack of resources, material and infrastructure, leading to loss of quality health care, increase the cost of health care and create more pressure on the major hospitals as well as the team of doctors and nurses.

Overcrowding is particularly severe than in the national hospital, where a team of skilled doctors and medical equipment modernization. Many important issues have been raised and resolved as (1) congestion, (2) medical procedures, (3) regulations binding (Ministry of Health) and (4) the effectiveness of the system management information. In particular, congestion and health procedures are important conditions causing the patient's waiting time increases.

The hospital is a complex system, the evaluation of health care systems, as well as the effectiveness of these policies is not easy. In this research, discrete event simulation (DES) is used to model operating in outpatient department because it is affected areas by overcrowding.

The main objective of this research is:

- Develop simulation models for investigated hospitals.
- Identify the bottlenecks and potential problems of the current operations through simulation.
- Propose solutions to enhance the efficiency of hospital operations, and compare them to the current practice.

The rest of this paper is organized as follows. The next section will present a literature review of studies on hospital operations, especially simulation based research. Section 3 provides the overview of the hospitals under investigation. Then, it describes the simulation models developed for our study. Results and discussions are given in Section 4. Finally, conclusions and future research directions are shown in Section 5.

2. LITERATURE REVIEW

Outpatient departments still have an exponential difference due to some extent of its independence despite of the similarity to impatient specialty units within hospital. There are consultants, treatment, diagnostic rooms with nurses in an outpatient department; however, the limitation in intersections was still found out to some remarkable amount of referral patients. Most of the important decision normally will be made by administrators without any approvals of the hospital management. In this thesis will reveal some review which simulate the way to improve the patient glow and also the way to schedule policy optimally.

This study briefly describes a basic design and development of a DES model which heavily relied on the object oriented paradigm (OOP) within a physician network. This thesis also shows a visual simulation environment to help illustrating and communicating the findings as well as the fully development process included detailed descriptions like data retrieval, modeling approaching, the covered patient pathways. That will assist us in deeply knowing the mechanisms of a physician clinic, which strengthen the theoretical factual foundations for making a firm decision (Swisher et al., 2001)

By exploiting a methodology with the interactions on system simulation to figure out the effectiveness of an outpatient transfusion centre, this thesis will also reveal the optimization and predict the target function. Multiple facilities and servers are assigned to varied services with a limited budget. In spite of the complex combination between elements, the easiness in using system which developed by manager still get the good future perspective and generate the high expectation to some certain. The focus may either be established based heavily on the quality level or performance leading to different recommendations (De Angelis et al., 2003).

The vascular-surgery outpatient service published a dedicated project at Good Hope Hospital mentioned about the software developed tool named Care Pathway Simulator (CPS). The CPS predicts the behaviors of the complex system by multiple patients routing differently in patients care pathways. The CPS are able to identify and eliminate the bottlenecks to enhance the effectiveness of capability to use. This project generates in 40% growth in capability of usage thanks to an optimized booking schedule. This growth was recorded and realized no additional supported resources (Dodds, 2005).

Calgary Laboratory Services located in Canada has investigated about a network of outpatient clinics with the goal to analyze the influence on the patient demand. It reveals that the number of laboratory facilities would be narrow down respectively from 25 to 18, 12 or 6 facilities. The development of isolated event simulation model is operated to anticipate the profit of pooling and to illustrate the optimum service provision. 18 facilities were suggested which are implanted in practice. The execution generates the perfectly surprising effect on patient demand described by system dynamics. That system is finally credited as the result for a great contribution to accomplish the simulation model so as to explain the overall system behaviors (Rohleder et al., 2007).

Apart from many general model of outpatient departments, the next study concentrate on the appointment schedule of doctors. This heuristically inform a purpose by designing for setting job salary up to 16 homoscedastic and equally- important customers. At the end of the day, the heuristic shows an average within 0.5% of the cost of the optimal policy (Robinson and Chen, 2003).

Additionally, another simulation model is to check out the various appointment schedules was conducted in the Ear, Nose, Throat (ENT) outpatient department near London. This model was relied on the feedback of consultants and experienced high level staff which reveal a truth that if clinics would start rightly, then 15 minutes on average of waiting will be saved. Moreover, the further analysis of the schedules depicts the grouping patient into large blocks should be avoided to gain another 8

minutes on patient wait (Harper and Gamlin, 2003).

The next research conducted at a local hospital in Taiwan-Chiavi which put all of the focus on the usage of simulation to cut off the out-patient queues of a dermatology outpatient department. By using "what-if" scenarios to simulation depict a considerable growth to performance if they add an extra session on Monday afternoon. Once implemented the length of stay reduces by 47 per cent, only 3 per cent of patients had a LoS of more than1.5 hours, the maximum queue length is reduced to a third of its original value, and the utilization of physicians is reduced 78 percent (Huarng and Lee, 1996).

The next study focus its results on how to minimize the patient queses at the Geroprefectural in Gifu Japan, using DES to test 4 different scheduling strategies B2 (Baily), Rising, 15MIN, and SPTBEG. The results finally reveal that the SPTBEG is the optimal for reducing waiting time, while 15MIN rule is the best to reduce physician idle time. The combination of a hybrid 15 MIN rising therefore would be most suitable (Wijewickrama, 2006).

There are 2 beneficial influences on applying simulation in outpatient departments generally. 1) Gain a better understanding of the mechanisms operating within complex system. 2) Apply "what-if" scenarios to the model without intervening with the current running system. Scenarios can be run, for example, to determine the best performing schedule rule (Wijewickrama, 2006). The other reviewed papers also make wide use of applying 'what-if'-scenarios, due to its easy application as an optimization strategy, especially when combined with visual interaction (Swisher et al., 2001). Simulation played an important role, especially when designing or instituting health care facilities. Downsizing, but still providing the essential services, is an issue which has been resolved by Rohleder et al. (2007), who evaluates the optimum amount of laboratory facilities to serve region.

3. SIMULATION MODELS FOR OUTPATIENT DEPARTMENTS

An hospital – Ministry of Public Health is one of a large General hospital in Ho Chi Minh city. The main purpose is health care for middle-senior official's member of the Communist Party of Vietnam, the armed forces, the people of the Southern provinces and neighborhood areas as protecting the health of Central. The precursor of the hospital is Liberation Army Hospital Southern K71.The hospital was established on 01/11/1975 with the name " Military Hospital" managed by the Ministry of National Defense. In 1987, transferred to the Ministry of Public Health and was renamed.

Currently, the hospital has expanded and developed more than 1000 beds, became a large center of geriatrics, cardiovascular, cardiology and emergency interventions, laparoscopic surgery in Ho Chi Minh city. From a general internal medicine and general mainly foreign, now, hospitals have developed most of the internal and external specialists in the direction of intensives, improve health care requirements with more than 1200 employees and 34 facilities.

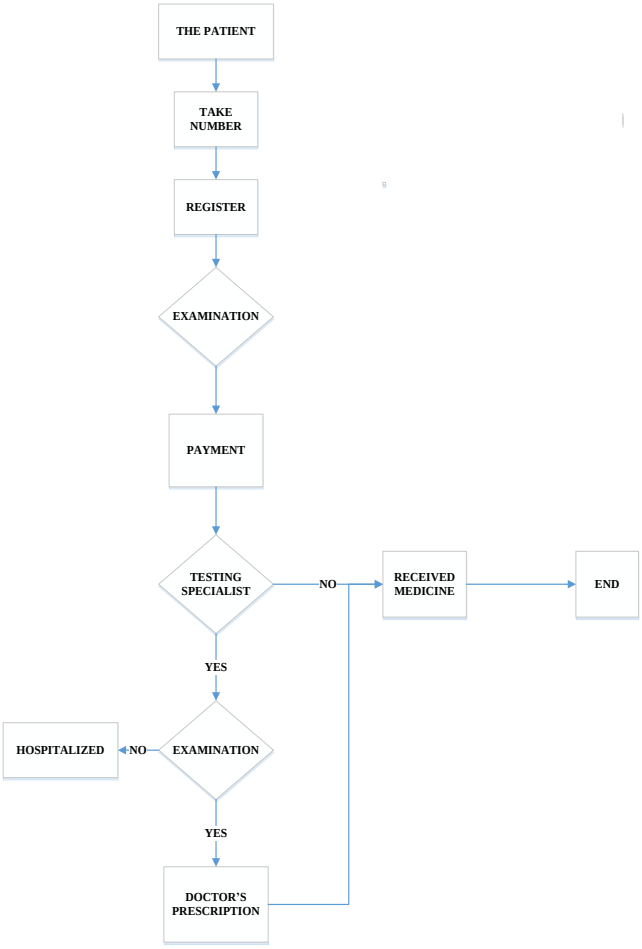


Figure 1 Patients flow in hospital

3.1 Data collection and Input Analysis

Data is collected through direct observations of the hospitals, particularly their outpatient departments. The data includes arrivals of patients during the day, types of patients (or without medical insurance), types of diseases, the number of function rooms (e.g., examination and testing), hospital resources (e.g., doctors and testing machines), the percentage of patients to each clinic, processing times of each function room, traveling distance/time between facilities and the route of testing for each type of disease.

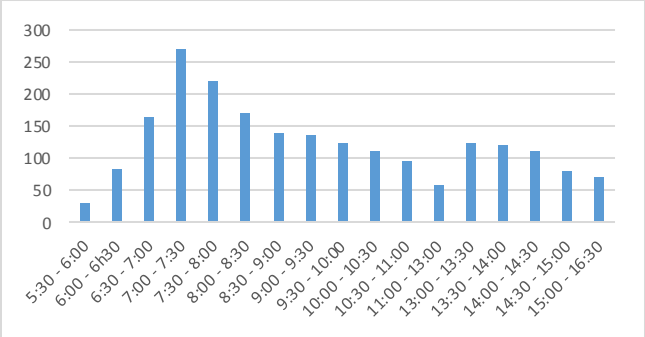


Figure 2 Arrival patients daily

Table 2 Research time for arrival of patients

No.	Time Slot	Arrival number patients	Distribution
1	5:30 - 6:00	31	EXPO(0.97)
2	6:00 - 6h30	85	EXPO(0.35)
3	6:30 - 7:00	163	EXPO(0.18)
4	7:00 - 7:30	269	EXPO(0.11)
5	7:30 - 8:00	221	EXPO(0.14)
6	8:00 - 8:30	172	EXPO(0.17)
7	8:30 - 9:00	140	EXPO(0.21)
8	9:00 - 9:30	136	EXPO(0.22)
9	9:30 - 10:00	124	EXPO(0.24)
10	10:00 - 10:30	112	EXPO(0.27)
11	10:30 - 11:00	96	EXPO(0.31)
12	11:00 - 13:00	57	EXPO(2.11)
13	13:00 - 13:30	124	EXPO(0.24)
14	13:30 - 14:00	120	EXPO(0.25)
15	14:00 - 14:30	111	EXPO(0.27)
16	14:30 - 15:00	81	EXPO(0.37)
17	15:00 - 16:30	72	EXPO(1.25)

All inputs are handled by using the input analyzer from the ARENA [21]. The distributions for our inputs are determined by analyzing the collected data. For examples, the distributions of processing times for each function room in this hospital are shown in the Table 3.

Table 3 Research time for Test Areas

No.	Testing room	Distribution	Unit
1	Ultrasound	UNIF(3.5,4.5)	Min
2	Electrocardiography	UNIF(5.5,6.5)	Min
3	Biochemical tests	TRIA(0.5,0.7,1.5)	Min
4	CT Scanner	TRIA(15,25,35)	Min
5	MRI	UNIF(30,45,60)	Min
6	X-Ray	TRIA(5,8,10)	Min
7	Endoscopy	UNIF(8.5,10)	Min

3.2 Validation

To validate our models, we looked at the difference between the output of the real systems and output of simulation model. Two-sample t-Test is used to compare the real output and simulation output, for each hour of a working day, of the function rooms. The validation results show that the hourly output of simulation models is not significantly different from the hourly output of actual hospitals (with the significant level α of 0.05). The results are also consistent when we compare the outputs for one working day and one week.

4. RESULTS

ARENA models are used to simulate the hospital operations. The simulated hospitals will operate from 5:00am to 4:00pm. Because this time frame, there are a number of patients (especially arrive in the afternoon) that remain in the system at the end of the day and are not able to receive testing results or to receive medicine at the pharmacy area. For each scenario (of a hospital and a specific policy), 30 independent replications are performed and the recorded information is used to evaluate the system. Several measures are used to assess the performance of hospitals:

- Utilization of each function room
- Waiting times of patients
- Total moving times of patients
- Throughput (the number of patients out of the system)

4.1 Performance of the current systems

The waiting times of patients are summarized in Figure 3. It is quite easy to see that there are a large number of patients waiting in the hospital for more than 3.5 hours (about 52.55% of patients served by the hospital). The number of patients waiting for more than two hours and less than 3.5 hours is about 32.77%. These results suggest that waiting times of patients are too long (for patients with or without waiting for testing results). The ratio between the total waiting times and the total processing (serving) times are 15.79 (this ratio is about 10.98 for patients without waiting for testing results), which indicates that patients waste too much time waiting as compared to the time they actually receive the service (consulting or testing). In some extreme cases, patients have to spend more than six hours waiting in the hospital (almost one working day). For each disease requires a different set of tests as suggested by doctors. Hence, the waiting times corresponding to each kind of disease are not the same.

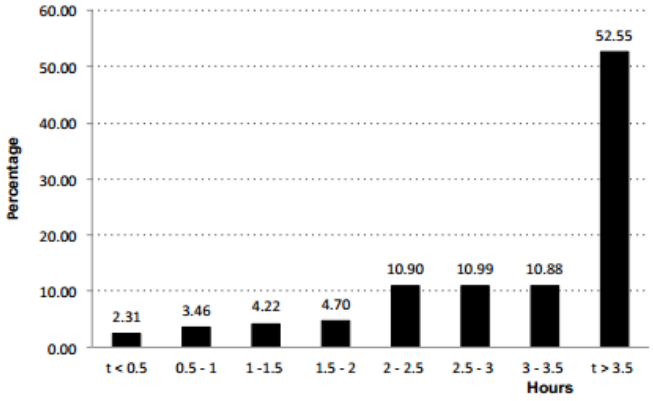
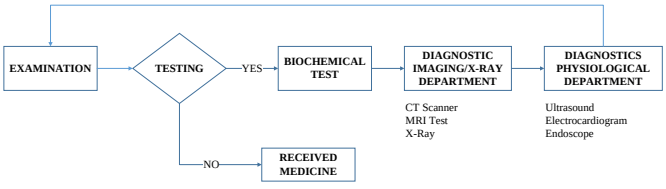


Figure 3. Waiting times of patients in the system

For testing, the CT test has the highest utilization of 0.9162, which indicates that the doctors of CT are always busy during working hours. In addition, Ultrasound and X-Ray also have high utilization; it is easy to understand as the patients take ultrasound and X-ray tests more often than other tests. From the results, it is clear that there are many problems with the current systems. The most obvious issue is the long waiting times, which make the patient tired, confused and frustrated. High utilization of several function rooms or departments is also a key issue and needs serious attentions.

4.2 Proposed solution

In order to reduce the waiting time and the confusion of patients, a new patient flow, with the support of the information system and the support of the testing rule, that are proposed in order to simplify and confused steps in the patient flows. In addition, the testing rule will be applied for patients is presented. In the new patient flow, the prepayment is applied at the registration and the information system is incorporated to improve the communication between different function rooms. In the new rule for testing, the patients have to follow step by step to implement this rule.



The results obtained from simulation show that the proposed patient flow can improve the performance of the hospitals. For the busier hospital, the throughput, the waiting times and moving times are improved by 0.47%, 7. 8% and 5% respectively. For the less busy hospital, the throughput and waiting times are improved by 2.4%, and 1 3.4% respectively.

These results suggested that the waiting times and moving times can be significantly reduced by eliminating unnecessary and confusing steps in the patient and information flows. In the proposed system, the moving time is reduced because patients do not need to travel back and forth between examining/testing rooms and payment counter. Even when the traveling is not significant, the total waiting times in the new system can be still reduced as the patient do not have to wait at the payment counter again.

4.3 Further discussion

This study shows that simulation is a useful tool to help us identify the problems within hospital operations, and evaluate the performance of different policies. Simplifying the patient flow and incorporating the information system is a promising and straightforward approach to improving the performance of hospital operations. However, under the current overloading issues, larger improvements are still expected. Regarding the high utilization of some departments, the hospital will need to come up with new plans to increase the capacity of these departments. Resources for high demand departments need to be invested to reduce the waiting times and reduce the stress of the current medical staffs. Spreading the workload of these major hospitals to local hospitals or healthcare centers is also an important macro strategy that will reduce the overloading issues in long term.

Another critical issue is the lack of effective appointment systems in these hospitals. As shown in Figure 2, patients in our studies have the tendency to queue up very early in the morning. This mainly comes from their strong desire to complete all required procedures within one day (so that the patients do not need to skip work again or they can return to their hometown at the end of the day in the case that they come from other provinces). Nevertheless, the hospital capacity is limited and unplanned patient arrivals will only build up large queues and cause long waiting times. An effective appointment system which takes into account the hospital capacity is a promising way to reduce the long waiting times of patients

5. CONCLUSIONS

Simulation is a useful tool to analyze and improve the performance of hospitals. In this study, we apply simulation to model two major hospitals in Ho Chi Minh City, Vietnam. The simulation results show that there are many problems or bottlenecks within the current systems and the waiting times of patients are still very long. A solution is proposed in this paper to improve the information flow and patient flow in these hospitals. In the proposed system, unnecessary and confusing steps in the hospital operations are eliminated. The simulation results of the proposed systems show that the waiting times and the moving times are significantly reduced as compared to the original systems. In future studies, we will focus more on the

app ointment systems and scheduling problems to further reduce the waiting times of patients and reduce the pressure for the medical staffs

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