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Reducing outpatient waiting time: a case study in Vietnamese private hospital

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Abstract—The outpatient department (OPD) is an essential feature of every hospital network around the globe. It is a complicated system with unique requirements to help patients avoid diseases, ensure speedy recovery without needing to be admitted for overnight care, and assist hospitals in conserving resources. As a result, one of the primary issues is ensuring its quality and client satisfaction. Although there are many factors at play, the goal of this study is to develop a discrete-event simulation model to reduce one of the most significant causes: the OPD's waiting time. The simulation model is based on a real-life case study of an OPD in a Vietnamese hospital where the patients decide the order of paraclinical procedures. Using real data from the hospital, we tested two strategies to improve the patient's decisions so that the waiting time in the system is reduced. Performance analysis and some managerial insights are used to look at how each different patient flow strategy affects the efficiency of the hospital.

Keywords— *Discrete event modeling and simulation; decision support; performance analysis; health care management; outpatient department.*

I. INTRODUCTION

“Private hospital” is now a rising trend in Vietnam as the number of private hospitals has increased steadily year by year. At the end of 2013, according to the data from the Ministry of Health in Vietnam¹, the number of hospitals recorded in the country was 1,180, including 150 facilities from the private sector. After 7 years, the number of hospitals has increased to 228 and has been predicted to exceed 300 by 2021. The advantages of private hospitals are the high-quality services and low waiting time they offer to patients [12]. The private hospital system contributes significantly to the provision of health services in Vietnam, providing 43% of outpatient services (patients receive treatments and go home the same day) and also 2.1% of total inpatient services. Therefore, improving and optimizing its performance (especially for outpatient services, which have a larger percentage) are critical goals for every private hospital. There are many evaluation factors to assert the quality of a medical institution, but in general, since it serves the patients, the quality of its performance will be reflected in the patients' experiences. Many researchers in the health care domain have suggested that waiting time is the most important

determinant of patient satisfaction and a crucial standard for every health care system [1][2][3][13][15][16][18]. This paper focuses on reducing the “patient waiting time” by providing a simulation model of a private hospital in Vietnam in a real case study. The specific unit of analysis is the Outpatient Department (OPD) of this hospital.

Gia Khang International Hospital (GIH), the selected hospital in this study, is a new private hospital that applies international medical standards of health care. Located in Ho Chi Minh City, Vietnam (the second largest city in Vietnam in terms of the area and the largest in terms of population), GIH has 9 operating rooms with ISO 6 standards, more than 200 high-class inpatient beds, and over 300 leading doctors, experts, and employees. They expect an increasing volume of patients in the next few years. One of the missions that GIH is committed to be is improving the quality of medical services by applying the advanced achievements of medicine, modern equipment, and efficient operational strategies. Discrete-event simulation is one of the most effective tools available to health care decision makers [1]. It is a method of re-creating how a system works and helping managers figure out how well changes to existing or new systems work and what kind of effects they have without wasting a lot of resources [6][11]. Discrete-event simulation has been widely applied in the health care area around the world. But in the Vietnamese health care system, where there are some differences, simulations of a complex system were rarely done.

This study, which is part of the GIH's global project, aims to understand and meet the hospital's needs in terms of improving customer satisfaction. The results contributed to reduce the patient waiting time in the OPD by simulating and assessing the impacts of different strategies for patient flow. Proposals of improvements to the hospital are also given.

The remainder of the paper is organized as follows: Section II provides some related works conducted by previous researchers and the contributions of this paper to the literature review. Section III aims to describe the flow and the data handling. A first simulation model is proposed in Section IV, along with a preliminary performance analysis of different improvement

¹ <https://moh.gov.vn/thong-ke-y-te>

strategies. Section V provides some managerial insights to improve performance in the future, and Section VI concludes the main points of the paper and gives some possible future works.

II. LITERATURE REVIEW

Hospitals are one of the most important pillars of any society. Therefore, in the race for development, researchers around the world were encouraged to contribute to improving the performance of medical facilities and increasing the satisfaction of patients. Having a good health care system is based on a number of things, such as safety, effectiveness, the quality of the facilities, and time.

In [7], "time" is one of the six bullet points for the aim of achieving a New Health Systems. In most departments of ambulatory services, reducing waiting times and harmful delays is one of the steps towards better treatment in health care services [3]. Nowadays, "waiting time" is a critical factor in customers' decisions when choosing a health care service provider [20][21][22]. Improving this factor will not just benefit the patients but also reduce the hospital's workload. For this situation, several operational researches have been conducted, and many solutions have been developed for solving this health care management problem. All the related work mentioned below focuses on reducing the waiting time of the patients in the system. First, we present relevant methods in the literature to minimize the waiting time. Secondly, we focus on the papers that used discrete-event simulation.

The main sections that have a significant impact on patient waiting time are the appointment and administration systems, resource availability, and patients' path and flow [13]. Gijo and Antony [8] used Lean Six Sigma methodology to identify the causes (machine, man, method, etc.) of non-value added from registration to medicine dispensing. They applied the Lean Sigma framework to the organization to define process performance, which is just as important as individual doctors. They had some managerial implications for the process and helped reduce the waiting time by more than 50%. Daldoul et al. [5] used a Mixed-Integer Linear Programming model to minimize the patient waiting time. They considered only the tactical level by optimizing the hospital's resources. Mardiah and Basri [16] used a queueing network and mathematical computation to provide suggestions for constructing an appointment system. The research considered the patients' flow and the system's capacity for improvement. Masoud et al. [17] developed an optimization model of an Emergency Department (ED) using a stochastic mathematical programming approach to minimize the waiting time.

Moreover, applications of discrete-event simulation were also conducted in the health care field. Chen Bai-lian et al. [4], using simulation of the OPD, suggested that the waiting time can be reduced through an appointment system and flexible demand-oriented doctor scheduling. Feili [6] constructed a simulation model of an ED in an Iranian hospital to analyze the patients' behaviors and defined the objective function to maximize

profit. Then the author optimized the function by reducing delay time within the constraints of cost and space. A new resource allocation was proposed to decrease the waiting time. Jamjoom et al. [13] evaluated and optimized the waiting time of patients by simulating different scenarios of scheduling based on types of patients. The difference between their OPD and ours is that any additional tests required after the consultation must be scheduled through a separate appointment system. In papers [9] and [11], the authors also applied discrete-event simulation to model an Ears-Nose-Throat department and improve its performance. On the one hand, Harper and Gamlin [11] improved the effectiveness of a hospital in the United Kingdom through better appointment scheduling. On the other hand, Haji and Darabi [9] pointed out the positive impact of an appropriate appointment policy in a hospital in Illinois. Najib Bin Salleh et al. [18] also used a discrete-event simulation approach to model the outpatient service system and demonstrated how efficient resource allocation can help to reduce the waiting time of patients. The outpatient flows were learned for each situation based on their characteristics and behaviors. Koo et al. [14] addressed patients flow problems at an endoscopy single unit by using discrete-event simulation. They discussed factors that contribute to the inefficient flow and determined the bottlenecks. They suggested patient scheduling and staff allocation to improve the flow of patients. Aeenparast et al. [1] showed that the waiting time can be reduced by dividing the patients into different groups based on their physical conditions. Pandit and Kulkarni [21] showed that to achieve operational excellence with good quality, effectively managing the patient flow in an outpatient unit is critical.

The simulation modeling of complex facilities with sophisticated logic has become feasible in health care. Therefore, there has been an increasing trend toward using discrete-event simulation tools to improve operations.

While most of the related works focused on the appointment system or resource allocation to reduce waiting time, our study focuses on optimizing patient flow in a private outpatient hospital in Vietnam. Different from other hospitals where the paths of the patients are mostly assigned or not mentioned, patients in the Vietnamese OPD have the right to decide where they will go after consultation. This is the random factor of this real case study. Therefore, simulations are conducted to assess the impact of good management of the patients' flow and, more specifically, to interfere with the patients' decisions for their next procedure.

III. OUTPATIENT HOSPITAL CASE STUDY

A. Description of the problem

The Vietnamese outpatient department system has its own specificities, which are described in this section. After the patient's arrival, he or she is going through the registration section, including booking appointments for the patient's arrival at the primary check-up. After that, patients proceed to the primary check-up and receive all the medical treatment in the next steps, including the doctor's consultation, paraclinical procedures, prescription, and receiving medicine.

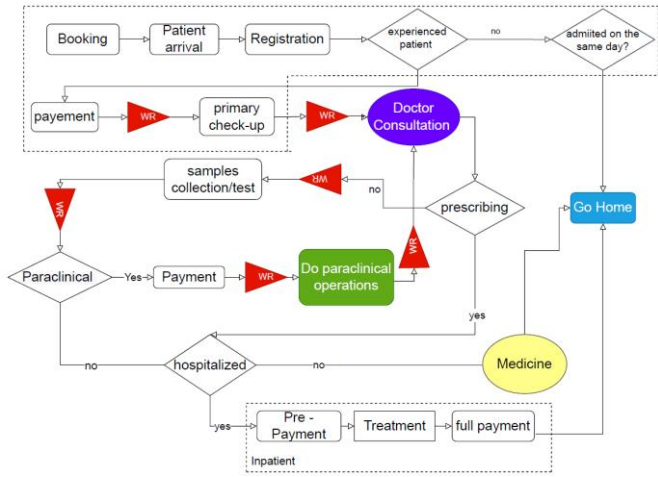


Fig. 1. Flowchart of the OPD in Gia Khang Hospital

Before each step, a waiting room is shared among all the patients. After the last consultation with a doctor, patients can only get the medicine when it is prescribed. They finally go home after the medicine is dispensed or get hospitalized. They may be hospitalized following a re-consultation with doctors or paraclinical tests. It is defined as inpatient treatment; therefore, this part will not be considered in the OPD system. Fig. 1 depicts key processes of the OPD system. The steps in the dashed boxes will not be considered in this study.

It is important to note that the paraclinical process involves several procedures (X-ray, Gastroscopy, Echography, Sample testing, etc.), and each patient does not have to undergo the same procedures. While in most OPDs around the world, instructions on where to go next are given to patients, in Vietnam, patients with their own test assignments randomly decide the paths of their procedure visits. Their decisions are based on their relative observations, causing the possibility of inefficiency and a high waiting time. Realizing this behavior, some strategies can be applied to interfere with the patient's flow in this specific step, optimizing the performance and decreasing the waiting time. based on their relative observations. All tasks are performed for the patients without making any new appointments.

B. Data collection

A raw set of real data from the medical record in October 2021 was retrieved from the hospital's information system. In total, 6220 patients were recorded as going to the OPD; the average number of patients per day fluctuates between 250 and 350, depending on the day. There are two types of data included. First, several qualitative data points (such as age, gender, different paraclinical procedure types, doctors assigned, departments, etc.) The second type of data is the quantitative data, which includes information about the patient's arrival time at the clinic, the first and second consultations, the beginning of paraclinical procedures, the time to receive medicine, and the time to leave the clinic. The detailed data about how much time patients wait and spend for each procedure in the paraclinical process was not available. Data cleaning is proceeded in order

to remove duplicates, handle missing data, and transform the data structure for simulation.

C. Assumptions

The data collected by the hospital is not completely supported for simulation. The reason is that discrete-event simulation is barely performed in the health care domain in Vietnam, although it is not a new tool. In order to model the system and simulate it with different strategies, a few assumptions were made.

- Since all the patients who visited the clinic had to go through the registration, primary check-up, and first payment regardless of their types, this workflow is considered independent and is not considered. The model starts with the doctor's consultation and moves through the paraclinical procedures, prescription, and receiving medicine.
- Through the data analysis, the number of patients who showed up for paraclinical procedures as Computed Tomography Scanner, Magnetic Resonance Imaging, ER, etc were recorded insignificant. The resources (machines, doctors) were assumed to be enough to handle them without causing a dramatic delay or a high waiting time for patients. These data were then removed from the model in order to simplify it. Four paraclinical procedures with a significant volume of patients were considered: Gastroscopy, Echography, X-ray, and Sample testing.

IV. SIMULATION

In this paper, an ARENA built-in VBA is used to model the behaviors and characteristics of the system.

A. ARENA model development

Fig. 2 represents the simulation model developed in this study. Following the first assumption, the model reproduces the journey of patients, focusing on the steps taken after patients received their first consultations. All the paraclinical procedures are determined at this point, and patients start to decide what to do next.

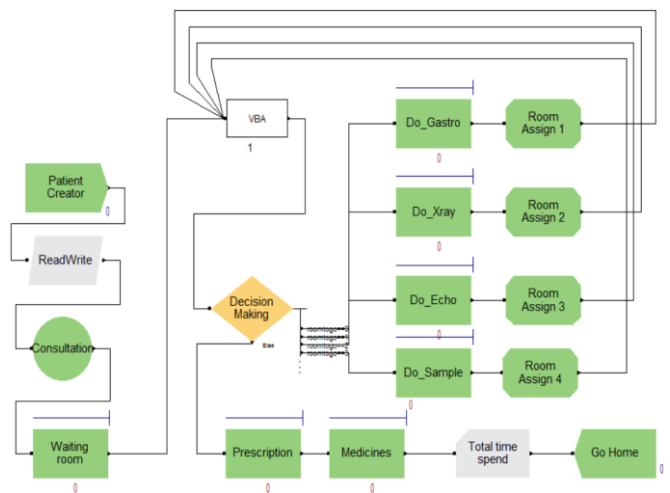


Fig. 2. Simulation model of the system in ARENA

Following the logic of the flow, after receiving the first consultation, patients have their instructions and randomly decide the paraclinical procedures. This randomness of the outpatient's decision-making when choosing their treatment procedure is modelled by using the VBA code. We choose to use the VBA block because it allows to try different strategies regarding the flow of the patients.

The input parameters are generated using the data collected from the hospital. The model uses the arrival time where patients start their first paraclinical procedure, the patients' needs (types of paraclinical procedures they have to do), the number of resources, and the average lead time for each station in the system (Table 1). A normal distribution is selected to represent the lead time of each station, based on hospital statistics on the average lead time of each procedure. Simulations are made for 19 days in the month. In order to simulate the real choice of the patients, we use a Random Choice (RC) strategy where the patients choose randomly the procedure.

To achieve our goal to reduce the waiting time, we propose to test two patient decision strategies:

1. Shortest Queue Length (SQL): patients choose the procedure which has the shortest queue length for their next destination
2. Shortest Waiting Time (SWT): patients choose the procedure which has the shortest waiting time for their next destination

B. Performance analysis

After simulating the three strategies for 19 days, the results are provided in Tables 3 and 4. Because the real waiting time are missing in the current data collection, the validation of the model is not completely finalized, but these first results can give an idea of the improvements than can be proposed. For each strategy, the average total waiting time (min) of each procedure and the total time spent (mins) in the system are provided in the columns *RC*, *SQL*, *SWT*. The columns *RC vs. SQL* and *RC vs. SWT* give the percentage of improvement of the strategies SQL and SWT compared to the random strategy.

TABLE I. HOSPITAL RESOURCES AND AVERAGE LEAD TIME (MINS)

Resources	Number	Average Lead Time
Doctors	13	10
Sample Testing	2	3
X-Ray	1	5
Echography	2	7
Gastroscopy	1	17
Pharmacist	4	3
Waiting Room	∞	

TABLE II. AVERAGE WAITING TIME (MINS) IN EACH PROCEDURE DURING THE WEEKDAYS.

		RC	SQL	RC vs. SQL	SWT	RC vs. SWT
Echo	avg	20,4	23,9	-17%	20,4	0%
	max	182,4	240,5		212,0	
Gastro	avg	179,9	160,9	11%	111,6	38%
	max	754,4	909,2		676,2	
Xray	avg	17,6	18,0	-2%	22,0	-25%
	max	154,3	192,5		208,3	
Sample	avg	31,2	23,4	25%	28,6	8%
	max	244,3	187,2		217,9	
Doctor	avg	0,0	0,0	0%	0,0	0%
	max	0,7	0,0		0,0	
Medicine	avg	1,8	2,1	-20%	2,7	-51%
	max	13,9	15,5		26,9	
Total time spent	avg	88,0	78,3	11%	71,0	19%
	max	900,5	990,7		795,2	

TABLE III. AVERAGE WAITING TIME (MINS) IN EACH PROCEDURE DURING THE WEEKENDS.

		RC	SQL	RC vs. SQL	SWT	RC vs. SWT
Echo	avg	22,4	25,9	-16%	23,4	-5%
	max	86,2	103,6		93,8	
Gastro	avg	281,6	236,6	16%	212,7	24%
	max	797,9	614,8		660,7	
X-ray	avg	12,6	25,3	-101%	30,6	-144%
	max	50,8	109,3		131,6	
Sample	avg	38,5	29,8	23%	33,4	13%
	max	136,1	96,8		124,7	
Doctor	avg	0,0	0,0	0%	0,0	0%
	max	0,0	0,0		0,0	
Medicine	avg	1,5	1,3	9%	1,6	-6%
	max	24,1	13,8		14,1	
Total time spent	avg	115,3	99,2	14%	93,9	18%
	max	892,1	637,2		720,4	

We propose to separate the results of the weekdays and the weekends.

We first observe that the gastroscopy procedure is the bottleneck in the hospital: the average waiting time is the longest for this procedure. For example, in Table 3, during the weekdays and for the random strategy RC, it is equal to 180 mins whereas it is equal to at most 31 mins on average for the other procedures. Hence, we are using the waiting time of the gastroscopy as a reference to evaluate the efficiency of the two proposed strategies, SQL and SWT.

When applying the SQL strategy, we assign patients to the procedures that have the lowest number of patients waiting. During the weekdays (resp. weekends), the waiting time is reduced by about 11% (resp. 16%) on average for the gastroscopy and by 25% (resp. 23%) on average for the sample procedure. When the patients do not choose the procedures randomly, it helps reduce the burden and overload by balancing the flow of patients among the procedures with a low queue, as we can observe with the increase in waiting time in the echography, X-ray, and medicine procedures. Overall, the SQL strategy is efficient since the total time spent in the system is reduced by 11% during the weekdays and by 14% during the weekends.

Although the SQL strategy helps reduce waiting time, there is still a situation where patients have to wait longer. It occurs when patients do not have information on the total lead time of each queue, which may vary differently regardless of the number of patients queuing. The SWT strategy is implemented on the assumption that a hospital can take a further step, which is calculating the waiting time in each queue and delivering the information to the patients. The results show that this strategy works better than the SQL strategy. The waiting time of the gastroscopy is reduced by 38% (resp. 24%) during the weekdays (resp. weekends) instead of 11% (resp. 16%) when using the SQL strategy. In addition, the total time spent is reduced by 19% during the weekdays and by 18% during the weekends.

The proposed SQL and SWT strategies are efficient even when the number of patients is higher. The percentage of improvement in the total time spent in the system is closed for the weekdays and weekends. For example, with the SWT strategy, we can improve the total time spent by 19% during the weekdays and by 18% during the weekends.

Additional experimentations are proposed to improve the waiting time at the bottleneck by adding one more resource. The positive result during the weekends when patients are high is shown in Table 4 with the SWT strategy. The new result shows a reduction of all the parameters compared to the currently available resources. This is considered a solution to reduce the waiting time of patients, regardless of the economic side of the hospital.

V. MANAGERIAL INSIGHTS

The results of the study offer the managers of the hospital some insights and propose some solutions to reduce the patient waiting time:

1. As is the real situation in the hospital now, the patients still choose their next procedure on their own or follow a common path. With such information as the shortest queue length or shortest waiting time of each procedure, the waiting time of the patients can be reduced.

TABLE IV. IMPACT OF ADDITIONAL MACHINE FOR THE GASTROSCOPY.

Parameters	1 machine	2 machines
Avg waiting time (min)	71	43
Avg total time spent (min)	94	66
Avg waiting time in Gastro queue	213	33
Nb of busy resources (unit)	0.6	0.6
Avg nb of patients waiting	7	1

TABLE V. NUMBER OF RESOURCES USED DURING THE WEEKENDS.

Resources busy	Average (units)
X-Ray	0.2
Echography	0.42
Gastroscopy	0.58
Sample Testing	0.66
Medicine	1.14
Doctor Consultations	1.92
Waiting Room	0

2. The results show that the bottleneck is the Gastroscopy procedure, where the waiting time or the number of patients waiting is always high. Realizing that the lead time is significantly higher than the other procedures, a change in resources could be a possible way to improve the performance of the system (Table 4). However, for the future, an economic analysis should be taken into account to evaluate the trade-off between hospital capital and patient satisfaction.

3. Looking further into the number of busy resources for each procedure (Table 5), although Gastroscopy is a bottleneck, the average resource used is only 0.56. It is obvious that the gastroenterologist's resources are not always put to good use. There are certain periods where patients come at the same time, so they have to wait longer. This could be improved by having Customer Service Representatives spread out appointments for patients who potentially have Gastroscopy on their medical records evenly.

4. The behaviors of the patients are very complex and random, so in order to have a more accurate model, the hospital should collect data in more detail, where each timeline of a patient should be recorded.

VI. CONCLUSIONS

This paper aims at improving the waiting time of patients during paraclinical procedures in an outpatient department of Vietnam's Gia Khang International Hospital. We developed a preliminary discrete-event simulation model using ARENA to improve the performance of this hospital. Two strategies were proposed to choose the order of the paraclinical procedures to visit: the shortest queue length and the shortest waiting time. The real behavior of the patients was represented by a random choice. Preliminary results using real data as input parameters show that the two strategies can help the hospital to decrease the total waiting time at the paraclinical procedures.

For future work, it would be interesting to collect more data about the patients of the studied hospital in order to run additional experiments. One important data currently missing is the real waiting time of the patients. Hence, it would be interesting to measure this waiting time to enable validating our simulation model by comparing the results of the experimentation with the real waiting time of the patients and to test the proposed strategies in the outpatient department.

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