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Improving Outpatient Service Quality in Department of Orthopedic Surgery by Using Collaborative Approaches

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***Abstract*—Nowadays, patient satisfaction is an important service quality index for many hospitals. In many Asian countries, healthcare system has a mixed-type registration which accepts for both walk-in patients and scheduled patients. It is different from western countries which accept only scheduled patients. A long waiting time (WT) of outpatient clinics is caused by this complex registration system. A survey questionnaire of patient satisfaction showed that the long waiting time is the most dissatisfied service quality for healthcare providers. This study focused on improving clinical services by using collaborative approaches to reduce outpatient waiting time for the healthcare providers. The collaborative approaches are scheduling approach with results presented in this paper and agent-based collaborative control system which is currently in progress. We collected and observed data for two months from real world situation and used data from hospital database for building and validating simulation models. Seven scheduling scenarios are performed: scenarios I adjusted proportion between walk-in patients and scheduled patients, scenario II-VI adjusted patient sequencing, and scenario VII adjusted late rate and applied a late policy for late patients. The scenario I (adjusting the proportion: 10% for walk-in patients and 90% for scheduled patients) has the highest percentage of waiting time improvement (average: 37.13 % for walk-in patients and 50.82 % for scheduled patients) compared with the other scenarios. The overall results show that adjusting proportion of patient scenario and patient sequencing scenario can improve patient waiting time in the mixed-type registration and are possible to apply to any outpatient clinics.**

Keywords—Scheduling approach; Agent-based model; Simulation; Outpatient waiting time

I. INTRODUCTION

In recent years, service sector has become one of the largest economic sectors. The quality of the service is a growing concern. Healthcare industry is one of the largest industries in the service sector [1]. The competition among healthcare providers in Taiwan has become intense because there are a lot of clinics and hospitals. Also, people in Taiwan can select healthcare providers freely under National Health Insurance (NHI). In order to create competitive advantages, it is critical for healthcare providers to increase the service quality level [2].

Much research indicated patient waiting time is a key performance index which affects patient satisfaction for medical industry [3, 4]. A long waiting time for an outpatient clinic is occurred not only in Taiwan (population 23,261,747), but also in many countries of Asia such as China (population 1,347,350,000), India (population 1,210,193,422) Japan (population 127,950,000), Thailand (population 67,041,000), etc. Those countries account for a total of 39.14% of the world population. In Taiwan, the registration type of healthcare system is a mixed-type registration which accepts for both walk-in and scheduled patients. This makes patients feel suffering about a long waiting time [4] because it is difficult for healthcare providers to manage scheduling. Therefore, the long waiting time is a problem that needs to be solved for increasing patient satisfaction level and service quality

In this study, we worked collaboratively with Taoyuan Armed Forces General Hospital (TYAFGH). Two approaches were used: scheduling approach and agent-based collaborative control system. TYAFGH is one of the regional medical centers in Taiwan and provides a wide variety of services that includes more than 20 clinical departments and supplies 689 patient beds. We focused on orthopedic department which has nine doctors and the patient volume is over 5500 for a year. In this department, there are three different teams: hands and foot, trauma and sports team. This research focuses on improving service satisfaction by reducing patient waiting time in the sports team. The longest average walk in patient and scheduled patient waiting time in a consultation section of the sport team were 124.36 and 91.8 minutes respectively. A survey questionnaire of service satisfaction was distributed by TYAFGH. It showed that waiting time is the most dissatisfied index among 26 indices for the hospital service in 2011. Hence, the waiting time is an urgent problem to be improved.

II. Literature Review

A. Outpatient Waiting Time

Outpatient waiting time means the time spent by an outpatient in a queue waiting to be served. Reducing long waiting time is a direct way to improve patient satisfaction and service quality. Groome and Mayeaux [5] illustrated factors that will affect waiting time such as arrival time, failure to attend, consultation time and registration time, etc. Wijewickrama and Takakuwa, 2006) [6] explored the long waiting time problem in outpatient clinics with a mixed-type registration and tested four scheduling rules to compare with the original case by simulation. The research discovered the rule that "First priority gives for shorter processing patients in consultation a physician" can obtain the best performance with waiting time. Su and Shih [7] used simulation approach to test four assumed models, such as changing patient sequencing, and assigning an interval time for scheduled patients, etc. Reynolds et al. [2] quizzed eight cases with different numbers of doctors and nurses that affect waiting time. Hung et al. [8] practiced a simulation model of patient flow in emergency department (ED) and tested the number of staffs caused the effect of waiting time. Vissers [9] determined suitable parameters of an healthcare schedule system that can affect waiting time by running simulation. Edwards et al. [10] performed computer simulation to investigate waiting time caused by serial process, quasi-parallel process and did sensitivity analysis to find out the best number of doctors and patients that can affect waiting time.

B. Simulation

Recently, simulation has been applied in many fields especially in the medical field. Rohleder et al. [4] used simulation model to identify improvement alternatives that include staffing levels, patient scheduling and an emphasis on staff arriving promptly via these alternatives to improve patient waiting time at an orthopedic outpatient clinic. Chen et al. [11] applied computer simulation to reduce outpatient waiting time. Reilly et al. [12] developed a delay-scheduling model for patients in a walk-in clinic and performed computer simulation to find out better parameters. Edward et al. [13] applied simulation approach for the preoperative assessment clinic and Joustra et al. [14] applied it for an endoscopy department. Both studies tried to decrease waiting time. Song et al. [15] improved the efficiency of the physical examination screening service of a large hospital system by a simulation approach. Shabtai [16] considered the decision-making of medical issues by using computer simulation. Dexter et al. [17] used computer simulation to model operating room (OR) scheduling. Gallagher et al. [18] performed the simulation in OR. It confers the greatest skills transfer to the in vivo surgical situation.

C. Agent-Based Model

Nowadays, an agent-based model becomes increasingly relevant for developing distributed and dynamic open systems. In this system, scheduling usually involves complex and non-deterministic interactions between different participants. Aburukba et al. [19] proposed a distributed multi-agent approach to model intelligent dynamic scheduling solution in advertisement. They believed that agent-based model is appropriate due to its characteristics to support both dynamic behavior and distributed structure. Foster et al. [20] reported that the applications of agents and multi-agent systems in the healthcare and clinical management environments are becoming a reality. Reynolds [21] revolutionized computer simulation of agents. He introduced individual perception, intelligence and behavior to his Boids agents, and therefore allowing emergent pattern based on a large group of constituent units to be simulated. Lanzola et al. [22] presented a methodology that facilitates the development of interoperable intelligent software agents for medical applications and propose a generic computational model for implementing them. Decker and Jinjiang [23] proposed a system to increase hospital efficiency using global planning and scheduling techniques. Generally, the nature of healthcare system generally involves the coordination of the effort of several individuals (e.g., physicians, nurses, social workers) with different skills and needs and located in different places, and usually there is no attention of a centralized coordinator, so the computerized systems can be difficult. Under these conditions, the agent-based model is a good option to be used in healthcare applications. Nealon and Moreno [24] claimed that agents offer a natural way of tackling inherently distributed problems with heterogeneous sources, by cooperating and coordinating their activities, and also acting pro-actively performing tasks that may be beneficial for the user. Besides, Fox et al. [25] identified other benefits of agents applied to healthcare: (a) agent technology offers advanced platforms for building expert systems to assist individual clinicians in their work and (b) distributed agent systems have the potential to improve the operation of healthcare organizations, where failures of communication and coordination are important sources of error.

III. Research Methodology

A. Description of Outpatient Department of Orthopedic Surgery

The department of orthopedic surgery operates from 8:30 am. to 10:00 pm. during weekdays. The sports team of department of orthopedic surgery has two doctors and totally five consultation sections per week. Fig. 1 shows the generalized patient flow diagram.

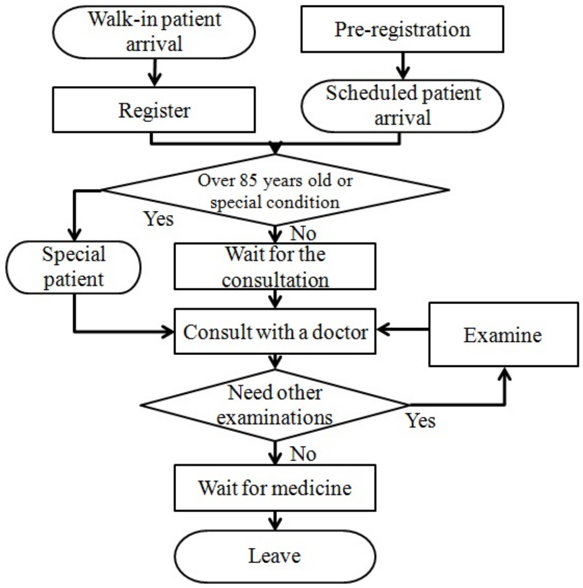

Fig. 1. Hospital service processes

The current process: a walk-in patient has to go to the registration counter for registering and getting a registration number, then goes to the clinic and waits for consultation, but a scheduled patient can directly go to the clinic and wait for consultation. Both types of the patients can be seen according to the registered numbers. For current scheduling policy, odd numbers are assigned to walk-in patients and even numbers are assigned to scheduled patients. TYAFGH has a special policy that patients who are over 85 years old or have a special condition have first priority to see a doctor. We defined these patients as “special patients” in our research. Late patients’ appointments will be postponed until the next three patients have been seen. After a patient consults with a doctor, it is then decided whether the patient needs to have a medical examination or not. If so, the patient goes to examine and will come back to see the doctor again. Doctor will prescribe medicine if required, and then the patient receives the medicine and leaves the hospital. If not, the patient receives a prescription, picks up drug, and leaves the hospital

B. Collect and Analyze Data

The patient data were collected from the sports team of the orthopedic outpatient clinic for two months. Then we analyzed data that we collected from the hospital and data from hospital database. The both data contain registration time, patient queues, clinic start time, first or subsequent consultation of patients, consultation period, and clinic end time and etc. Patient behaviors, such as arrival time, consultation time, late rate, no-show rate, examine time and examination rate, would be explored.

C. Build a Simulation Model

For building a simulation model, department of industrial engineering and management of a university worked collaboratively with department of orthopedic surgery of TYAFGH to design a simulation model. In this study, we built five simulation models by using simulation software package “Arena version 13.9”. The simulation models would represent the current service processes of orthopedic clinic and show the results after applying proposed scenarios. As a work in progress, we are applying agent-base collaborative control system into the simulation models and we will compare the results between scheduling approach results and agent-base models results.

D. Validate a Simulation Model

The research used four indices namely the number of patients, throughput time, waiting time, and doctors’ utilization to validate the five simulation models. For simulation results, we used the average results of outputs. To converge on the output, this research ran 300 times of each simulation model.

IV. Definitions Of Scenarios

In this research, we created seven scenarios to improve long patient waiting time for the hospital. The hospital limited the number of walk-in patients and scheduled patients per consultation section up to 30 and 40 respectively. This research applied seven scenarios for each consultation section. Seven scenarios are described as follows:

A. Scenario I : Adjusting the Proportion of Walk-in Patients and Scheduled Patients

For this scenario, we assigned the different proportion between walk-in patients and scheduled patients to reduce patient waiting time. The current proportion between walk-in patients and scheduled patients is scheduled patients occupy approximately 60% and walk-in patients occupy approximately 40%. This study adjusted proportion of walk-in patients and scheduled patients from 10%:90% to 20%:80%, 30%:70%, 50%:50%, 60%:40% and 80%:20% respectively.

B. Scenario II: Adjusting Sequence of Walk-in Patients and Scheduled Patients

The current patient scheduling policy is as follows: the odd numbers are assigned to walk-in patients and even numbers are assigned to scheduled patients. By using this policy, the first patient will be a walk-in patient, the second patient will be a scheduled patient, the third patient will be a walk-in patient, the forth patient will be a scheduled patient, and the fifth patient will be a walk-in patient and so on. We defined this sequence as “W1S1.” In this scenario, we adjusted the sequence of walk-in patients and scheduled patients. We first adjusted the sequence from W1S1 to W2S1, W3S1 and etc.

C. Scenario III: Assigning Front Numbers to Walk-in Patients and Later Numbers to Scheduled Patients

This scenario was designed under hypothesis that we assumed this scenario would have reduced a lot of waiting time if the walk-in patients could be seen first. A doctor will see all walk-in patients first; after that, scheduled patients will be seen.

D. Scenario IV: Assigning Front Numbers to Scheduled Patients and Later Numbers to Walk-in Patients

This scenario was designed for comparing with scenario III. By using the scenario, a doctor will see all scheduled patients first; after that, walk-in patients will be seen.

E. Scencenario V: Assigning Some Front Numbers to Walk-in Patients and Later Numbers to Walk-in and Scheduled Patients

First, we assigned some front numbers to walk-in patients and later numbers to walk-in and scheduled patients. This can be briefly described by an instance as follows. We assigned the first five numbers to walk-in patients, so the first, the second, the third, the fourth, and the fifth patients will be walk-in patients; after that, the sixth patient will be a walk-in patient, the seventh patient will be a scheduled patient, the eighth patient will be a walk-in patient, the ninth patient will be a scheduled patient and so on. We defined this term as "W5W1S1" for this scenario.

F. Scenario VI: Assigning Some Front Numbers to Walk-in Patients and Assigning Later Numbers to Walk-in and Scheduled Patients with Different Patient Sequencing

We assigned some front numbers to walk-in patients and later numbers were assigned with different patient sequencing to walk-in and scheduled patients. For example, we assigned the first five numbers to walk-in patients, and later numbers were assigned as the sequence "W2S1". We defined it as "W5W2S1". The sequence of this scenario will be: the queue numbers 1 to 5 are assigned to walk-in patients, the queue numbers 6 and 7 are assigned to walk-in patients, the queue number 8 is assigned to a scheduled patients, the queue numbers 9 and 10 are assigned to walk-in patients, the queue number 11 is assigned to a scheduled patient and so on.

G. Scenario VII: Adjusting the Late Rate and Applying a Late Policy for Late Patients

We designed this scenario and adjusted the late rate and applied a late policy to late patients for testing the effects of long waiting time. In the beginning, we adjusted the late rate for doing a sensitivity analysis. Then, in addition to that, but we also applied the late policy for the late patients. This way, we can prove that whether the late patients are the impact factor of long waiting time or not.

V. SIMULATION RESULTS

A. Analyze Results

This research applied seven scenarios for each consultation section. The different scenarios give different results, and the results are shown in table I-VII.

TABLE I. THE WAITING TIME IMPROVEMENT FOR SCENARIO I

Consultation Section	Patient Type	Waiting Time Improvement (%)							
		W10%:S90%	W20%:S80%	W30%:S70%	W43.5%:S56.5%	W50%:S50%	W60%:S40%	W70%:S30%	W80%:S20%
Dr. A (morning)	walk-in	49.95	34.47	15.50	0	-5.14	-8.68	-7.08	0.47
	scheduled	63.97	37.36	11.04	0	2.33	11.19	27.17	48.56
Dr. A (afternoon)	walk-in	42.07	23.46	9.19	0	-8.51	-11.09	-9.18	-0.90
	scheduled	54.59	29.03	8.27	0	0.15	8.24	20.88	36.85
Dr. A (evening)	walk-in	26.82	21.17	9.92	0	-2.69	-0.91	9.62	25.94
	scheduled	51.72	28.41	9.87	0	4.16	14.90	29.06	45.57
Dr. B (morning)	walk-in	25.62	16.73	6.78	0	-1.06	6.48	16.96	33.31
	scheduled	47.02	22.39	4.38	0	5.43	17.91	32.64	49.91
Dr. B (afternoon)	walk-in	27.93	17.60	7.08	0	-3.75	-2.26	3.91	14.54
	scheduled	34.70	16.70	5.40	0	3.71	13.76	25.86	42.02

TABLE II. THE WAITING TIME IMPROVEMENT FOR SCENARIO II

Consultation Section	Patient Type	The Waiting Time Improvement (%)			
		W2S1	*W3S1*	*W4S1*	*W5S1*
Dr. A (morning)	walk-in	19.45	26.11	29.62	31.22
	scheduled	32.85	44.22	47.56	46.98
Dr. A (afternoon)	walk-in	19.06	24.82	28.83	27.98
	scheduled	53.08	58.08	61.71	60.23
Dr. A (evening)	walk-in	23.74	31.41	35.81	38.61
	scheduled	37.20	44.72	48.09	48.48
Dr. B (morning)	walk-in	25.69	32.06	36.07	37.96
	scheduled	23.63	27.30	26.59	28.11
Dr. B (afternoon)	walk-in	15.18	19.35	22.23	24.85
	scheduled	45.12	48.66	50.06	52.55

TABLE III. THE WAITING TIME IMPROVEMENT FOR SCENARIO V

Consultation Section	Patient Type	The Waiting Time Improvement (%) When The Front Numbers Are Reserved For Walk-In Patients			
		Front 5 numbers	*Front 10 numbers*	*Front 15 numbers*	*Front 20 numbers*
Dr. A (morning)	walk-in	14.73	27.14	35.94	40.37
	scheduled	6.84	27.04	47.70	69.95
Dr. A (afternoon)	walk-in	17.57	26.27	33.76	37.95
	scheduled	15.28	33.26	55.11	74.49
Dr. A (evening)	walk-in	20.30	34.53	44.67	49.12
	scheduled	12.98	32.14	54.19	70.55
Dr. B (morning)	walk-in	21.69	34.03	46.28	51.40
	scheduled	11.84	30.04	52.06	69.79
Dr. B (afternoon)	walk-in	14.97	23.25	28.23	31.49
	scheduled	3.53	19.45	38.22	58.05

TABLE IV. THE WAITING TIME IMPROVEMENT FOR SCENARIO III AND IV

Consultation Section	Patient Type	The Waiting Time Improvement (%) When Arrival Time of Scheduled Patients Starts After Clinic Start Time							
		30 mins (S III)	*30 mins (S IV)*	*60 mins (S III)*	*60 mins (S IV)*	*90 mins (S III)*	*90 mins (S IV)*	*120 mins (S III)*	*120 mins (S IV)*
Dr. A (morning)	walk-in	37.96	9.66	39.78	20.30	41.52	33.52	41.63	51.46
	scheduled	-36.52	62.19	2.83	67.57	36.78	71.18	67.52	75.90
Dr. A (afternoon)	walk-in	36.87	-7.92	37.16	6.95	38.35	25.80	39.16	45.30
	scheduled	-6.98	54.67	20.47	61.00	50.01	65.28	73.33	68.28
Dr. A	walk-in	45.23	15.90	48.03	40.44	49.50	65.97	49.99	81.77

(evening)	scheduled	-11.04	56.12	30.78	61.20	61.86	65.58	79.97	66.23
Dr. B (morning)	walk-in	43.99	15.58	49.10	46.92	51.91	71.91	52.97	85.14
	scheduled	-6.12	61.46	28.30	66.39	61.55	68.64	80.34	69.17
Dr. B (afternoon)	walk-in	29.76	22.23	31.10	50.69	32.29	75.36	32.94	86.95
	scheduled	-0.52	53.24	34.32	56.11	66.42	57.80	83.64	58.33

S: Scenario

TABLE V. THE WAITING TIME IMPROVEMENT FOR SCENARIO VI

Consultation Section	Patient Type	The Waiting Time Improvement (%)								
		W5W2S1	*W5W3S1*	*W5W4S1*	*W10W2S1*	*W10W3S1*	*W10W4S1*	*W15W2S1*	*W15W3S1*	*W15W4S1*
Dr. A (morning)	walk-in	26.63	30.77	33.41	31.47	34.59	35.51	35.13	36.85	37.53
	scheduled	21.50	37.29	45.29	29.79	42.93	47.49	32.79	45.00	50.03
Dr. A (afternoon)	walk-in	27.96	31.12	32.54	32.06	33.64	34.91	35.73	36.09	36.75
	scheduled	40.65	51.66	57.39	46.92	56.10	59.35	52.89	57.94	63.43
Dr. A (evening)	walk-in	34.44	38.80	41.35	39.50	42.53	43.42	44.19	44.73	46.10
	scheduled	51.55	63.41	69.76	58.30	68.09	71.15	64.56	69.76	71.76
Dr. B (morning)	walk-in	37.44	42.41	44.45	41.63	45.79	46.75	45.77	47.51	49.56
	scheduled	56.61	66.42	70.72	59.31	69.40	71.52	65.99	70.56	75.28
Dr. B (afternoon)	walk-in	24.94	28.01	28.75	28.26	29.39	30.41	30.14	31.08	31.28
	scheduled	59.51	69.46	71.32	66.14	70.43	76.26	69.41	75.48	75.16

TABLE VI. THE WAITING TIME IMPROVEMENT FOR SCENARIO VII

Consultation Section	Dr. A- Morning		Dr. A- Afternoon		Dr. A- Evening		Dr. B- Morning		Dr. B- Afternoon	
	W-WT	*S-WT*	*W-WT*	*S-WT*	*W-WT*	*S-WT*	*W-WT*	*S-WT*	*W-WT*	*S-WT*
Late policy 3	124.36	76.75	122.57	91.8	77.75	61.8	65.15	67.8	81.36	71.45
Late policy 5	122.88	77.59	118.28	93.74	77.34	61.23	63.22	68.02	80.33	71.19
Late policy 10	124.5	75.8	125.17	90.48	80.54	59.25	64.63	68.71	81.61	73.72
Late policy 15	123.92	75.1	124.78	90.46	80.68	59.52	64.4	69.04	81.64	73.5

W: walk-in patient; S: scheduled patient; WT: waiting time

VI. CONCLUSIONS

A. Conclusions & Discussions

Nowadays, service quality is getting important in healthcare industry. It always concerns with patient satisfaction. In previous research, it showed that waiting time is a key performance index of patient satisfaction. This research proposed seven scenarios to promote patient satisfaction by reducing patient waiting time in an outpatient clinic. The research built five simulation models that represent the complexities of the healthcare service processes. Based on the results of throughput time and waiting time after we applied the scenarios into the simulation models, we could conclude the following: walk–in patients are an interference factor in a mixed-type registration. In scenario I, we adjusted the proportion of walk-in patients and scheduled patients to smoothen the service process. From the results of scenario I, it shows that when the proportion of walk-in patients is getting lower, the waiting time is also decreasing. For scenario II- VI, we adjusted the patient sequencing in different ways. In our study, we found out that adjusting patient sequencing is an effective approach to improve patient waiting time. From the results, it can be seen that the waiting time improvement of scenario III, scenario IV and scenario VI are better than scenario II and V. In scenario III and IV, a doctor will either see all the walk-in patients and then see all the scheduled patients or see all the scheduled patients, and then see all the walk-in patients. We assigned the different arrival time for scheduled patients in scenario III and for walk-in patients in scenario IV, and the waiting time improvement is different. In scenario VI, we could claim that when the front numbers are assigned to walk-in patients increasingly, the waiting time improvement will also increase. The results of scenario VII show that the late patients are not a strong interference factor and the late policy for late patients has no significant effect on improving outpatient waiting time. Overall, walk-in patients' behaviors in an outpatient clinic of a mixed-type registration system are difficult to predict. In this research, we adjusted the proportion of walk-in and scheduled patients, adjusted the sequence of walk-in and scheduled patients, and applied the late policy for late patients to reduce patient waiting time. Before we chose the scenarios to apply to the department of orthopedic surgery, we had a brain storm discussion between department of industrial engineering and management and department of orthopedic surgery. From the results, scenario I (adjusting the proportion of patients: 10% for walk-in patients and 90% for scheduled patients) and scenario V (assigning front 15 numbers to walk-in patients and later numbers to walk-in and scheduled patients) are highly suggested. Both of them could improve the patient waiting time (scenario I: average improvement of walk-in patient waiting time is 37.13% from 92.24 minutes to 59.25 minutes and average improvement of scheduled patient waiting time is 50.82% from 73.92 minutes to 36.35 minutes; scenario V: average improvement of walk-in patient waiting time is 36.91% from 92.24 minutes to 59.45 minutes and average improvement of scheduled patient waiting time is 49.59% from 73.92 minutes to 37.26 minutes) in department of orthopedic surgery.

B. Future Directions

In our research, we applied seven scenarios to different consultation sections. At present, we are working on applying agent-based collaborative control system into the simulation models. It will be interesting to compare the results of agent-based collaborative control system with that of the scheduling approaches presented in this research.

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