Patient's Waiting Time Reduction in Outpatient Department

Natchaya Lailomthong, and Seeronk Prichanont

***Abstract*—** Outpatient department has become an essential part of the hospital due to the fact that it is the first step of the treatment system. This leads to the long waiting times especially in public hospitals in Thailand. Patients always have long waiting times for a treatment followed by short consultations. In this study, Operation Research is applied to improve the system. We found out that the reason for long waiting times is that there are too many patients who come in at the same period of time. A discrete event simulation of the outpatient department was developed to examine the system by applying an appointment system to reduce the congestion of patients. The results identified the best appointment system suited for the outpatient department which has more walk-in patients and a high variability of consultation time. This could reduce the waiting times of patients without adding more resources.

***Keywords*—**Appointment system, Health system analysis, Outpatient department, Simulation

I. Introduction

THE case study hospital is a public hospital under Ministry of Public Health located in Chonburi, Thailand. Public hospitals in Thailand faced the same problem in an increasing of patients while there are few doctors available. We collected the data from the hospital's database. There are about 200 patients in the outpatient department per day. 30 percent of patients are patients with appointments. The average total waiting time of patients is 2 hours. The arrival pattern of patients mostly congested around 7 to 8 AM. This caused the patients who came earlier had more waiting times than the ones who came afterwards. There are different reasons for long waiting times but the major reason in this study is the imbalance of the amount of patients in each period. The objective of this study is to apply the appointment system for appointment patients through the simulation model in order to reduce the patients' waiting times.

There are many researchers who study about Appointment System. The effective Appointment System can increase doctors' utilization and also reduce patients' waiting times. There are two components of an Appointment System: *Appointment Rules and Sequencing Rules* [1].

The appointment rule consists of number of patients appointed in one period (block size), the number of patients at the beginning of the clinic (initial block), and the interval between the appointments. With the combination of these variables, there are several appointment rules.

The single-block system (Fig. 1) is the appointment rule which mostly used in the public hospitals in Thailand due to the convenience and the less of doctor's idle time. However, all patients come simultaneously causing the congestion and exceeding waiting time [2].

Fig. 1 Single-block System

The individual-block/fixed interval (Fig. 2) calls patients one by one with fixed time. Reference [3] specified interval equal to the doctors' average service time whereas [4] set interval less than the average service time. This system is suitable for the clinics with a high service time and low variance of service time.

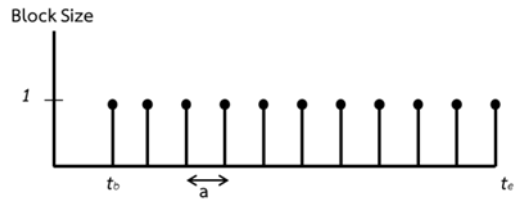

Fig. 2 Individual-block/Fixed interval System

In multiple-block/fixed-interval (Fig. 3), many patients are appointed to the clinic. Reference [3]-[5] examined this system assigning the interval two times of average service time. Reference [6] offered to extend the interval in case of there are walk-in patients and emergency patients.

Natchaya Lailomthong is with the Department of Industrial Engineering, Chulalongkorn University, Bangkok, 10330 Thailand. (corresponding author's phone: +6681-625-5512; e-mail: natchaya.l@hotmail.com).

Seeronk Prichanont is with the Department of Industrial Engineering, Chulalongkorn University, Bangkok, 10330 Thailand. (e-mail: seeronk@gmail.com).

Sponsored by Thai Health Promotion Foundation, Bangkok, 10120 Thailand. (website: http://en.thaihealth.or.th)

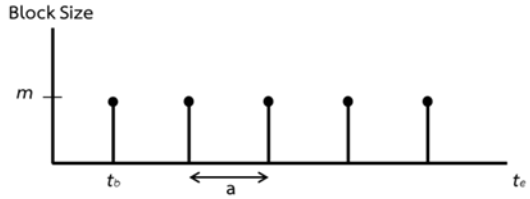

Fig. 3 Multiple-block/Fixed-interval System

The variable-block/fixed interval (Fig. 4) has different block size. We may investigate this system together with the sequencing rule.

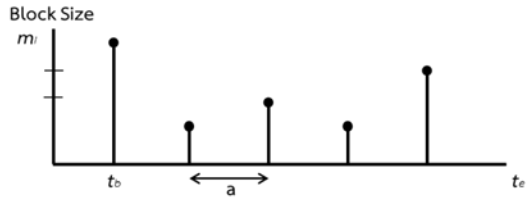

Fig. 4 Variable-block/Fixed interval System

The individual-block/variable-interval (Fig. 5) appoints one patient with the varied interval. Reference [7] applies this rule by appointing patients earlier to reduce doctors' idle time.

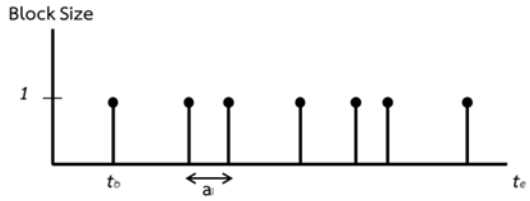

Fig. 5 Individual-block/Variable-interval System

The multiple-block/variable-interval system (Fig. 6) is similar to the previous one, but appoints more patients.

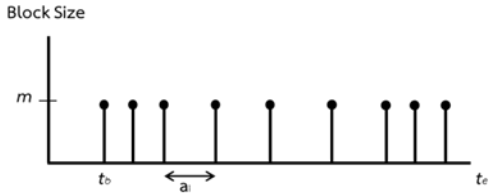

Fig. 6 Multiple-block/Variable-interval system

Moreover, the appointment system mentioned above can be added with the initial block which appoints the number of patients at the beginning of the clinic (Fig. 7). Reference [8] applied this rule by appointing 2 patients and designated as 2BEG.

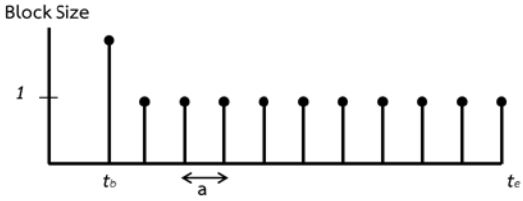

Fig. 7 Appointment System with Initial Block

The sequencing rule is the rule which classifies patients in order to increase the accuracy of the appointment system. Patients can be classified in term of service time, arrival time, and cost of waiting [1]. Most of the study classifies patients into the group of low and high service times. From [3], [9], and [10], we can make a summary about the sequencing rule. FCFA is the one with no sequencing rule because assumes patients to be homogeneous, alternate patients group by group (LHLHLH…), alternate patients every n groups (LLLLHHHHLLLL…), any groups come first (LLLLLLHHHHHH…) and any groups come at the beginning and the end of clinic session (LLHHHHHLL).

Although this subject has been studied in many prior researches, there is a gap adopting into practice. A different clinical environment always has a different appointment system [11]. Most of the researches have focused on applying appointment systems to the internal medicine department or the clinic with long service times and few walk-in patients. But in this study, we provide an appointment system for the clinic in which service times are low and inconsistent. Furthermore, we considered a number of walk-in patients, patients' unpunctuality, and no-shows as they are the characteristics of most public hospitals in Thailand.

II. Description of Outpatient Service Process

The model simulates the outpatient department on Monday to Friday 5AM to 12PM. Patients are divided into appointment patients and walk-in patients. Since the case study hospital located in an industrial area, there are 70 percent of walk-in patients. First, patients have to register at the information desk and wait for medical history taking by nurses. There are 4 stations for medical history taking, two for walk-in patients, one for appointment patients, and another for social security patients. After the history taking, if patients need the laboratory examination, they are sent to laboratory room. If not, they are sent to wait for the consultation. The consultations are divided to major specialty diseases and general disease. Major specialty diseases consist of surgery, medication, pediatric, and obstetric which have one consultation room for each type. Most of the patients are general disease; therefore, hospitals provide 6 rooms for general cases. After the consultation, patients who need to make an appointment will go to the appointment station. Then, they wait for medicines, if necessary, and go back home.

At present, the department appoints patients to the clinic

daily by appointing every patient in the same time (8AM). The nurses make an appointment by just followed the duration that doctors specified; therefore, it is no pattern of appointment system. In addition, when patients come at appointment date, it is possible that they have not consulted with the same doctor.

III. Input Analysis

The input data are taken from hospital database system called "HosXP". HosXP is the software mostly used in public hospital in Thailand. The database records the time in every station of the process in outpatient department. It also records patients' treatment history, patients' background, and personal information etc. We take the information of May 2013 to enter to the model consisting of 3686 patients.

A. Inter-arrival Time Analysis

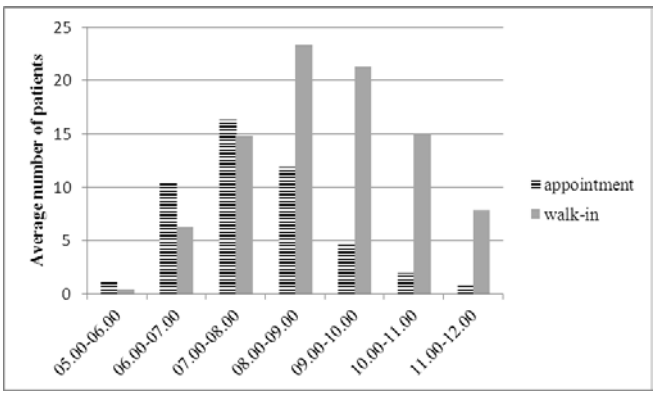

Fig. 8 Number of patients in each period

As shown in fig. 8, two types of patients have different arrival pattern. Even though the department appoints every patient at 8 AM, patients still come at various times because of the unreliability of the appointment system. Appointment patients tend to arrive to the clinic earlier. It is obvious that the number of patients in each hour is different. The statistical method (ANOVA) is used to test the mean inter-arrival time between each day in May 2013. Supposing that

H_0 : Mean inter-arrival time between the day is not different.

H_a : Mean inter-arrival time between the day is different.

The result shows that mean inter-arrival time between the days is not different at 95% confidence interval, so the 31 days of the data are assumed to be homogeneous. The pattern of inter-arrival time can divide into two groups, patients with appointment and walk-ins. Each type is also distributed to every hour. Then, group of data are fitted for the best distribution by input analyzer in ARENA. The inter-arrival time distributions are shown in table I and table II.

TABLE I
APPOINTMENT PATIENTS' INTER-ARRIVAL TIME DISTRIBUTION

Interval	Distribution
05.00-06.00	EXPO(14.8)
06.00-07.00	EXPO(5.39)
07.00-08.00	EXPO(3.73)
08.00-09.00	EXPO(5.37)
09.00-10.00	EXPO(12.5)
10.00-11.00	3 + EXPO(19.2)
11.00-12.00	EXPO(22.2)

TABLE II
WALK-IN PATIENTS' INTER-ARRIVAL TIME DISTRIBUTION

Interval	Distribution
05.00-06.00	1 + EXPO(24.3)
06.00-07.00	EXPO(8.12)
07.00-08.00	EXPO(4.09)
08.00-09.00	EXPO(2.84)
09.00-10.00	EXPO(3.12)
10.00-11.00	EXPO(4.64)
11.00-12.00	EXPO(8.01)

B. Service Time Analysis

It is a fact that different staffs have different service time, so it is also needed to test with ANOVA. The same hypothesis is used. The results show that the mean service time for nurses is not different significantly, but for doctors, it is different in general practitioners between extern and intern. Extern doctors will make longer service time. Thus, the model has to include the probability of consulting with which type of doctors. Service times in each station are fitted for the best distribution by input analyzer in ARENA. The distributions are shown in table III

TABLE III
SERVICE TIME DISTRIBUTION

Stations	Distribution
Information desk	LOGN(0.353, 0.292)
History taking (general)	LOGN(2.7, 1.41)
History taking (appointment)	LOGN(2.08, 1.09)
History taking (social security)	LOGN(2.18, 1.3)
Appointment station	LOGN(2.33, 1.47)
Walk-in station	LOGN(1.85, 1.27)
Surgeon	LOGN(4.49, 2.53)
pediatrician	1 + GAMM(3.58, 1.34)
obstetrician	0.999 + WEIB(6.73, 0.875)
physician	0.999 + EXPO(7.05)
general practitioners (intern)	EXPO(4)
general practitioners (extern)	EXPO(5.2)
Pharmacy	1 + WEIB(7.1, 0.689)
Laboratory	1 + WEIB(27.4, 1.72)

IV. Simulation Model

The process in the simulation model is represented by the flow process in fig. 9.

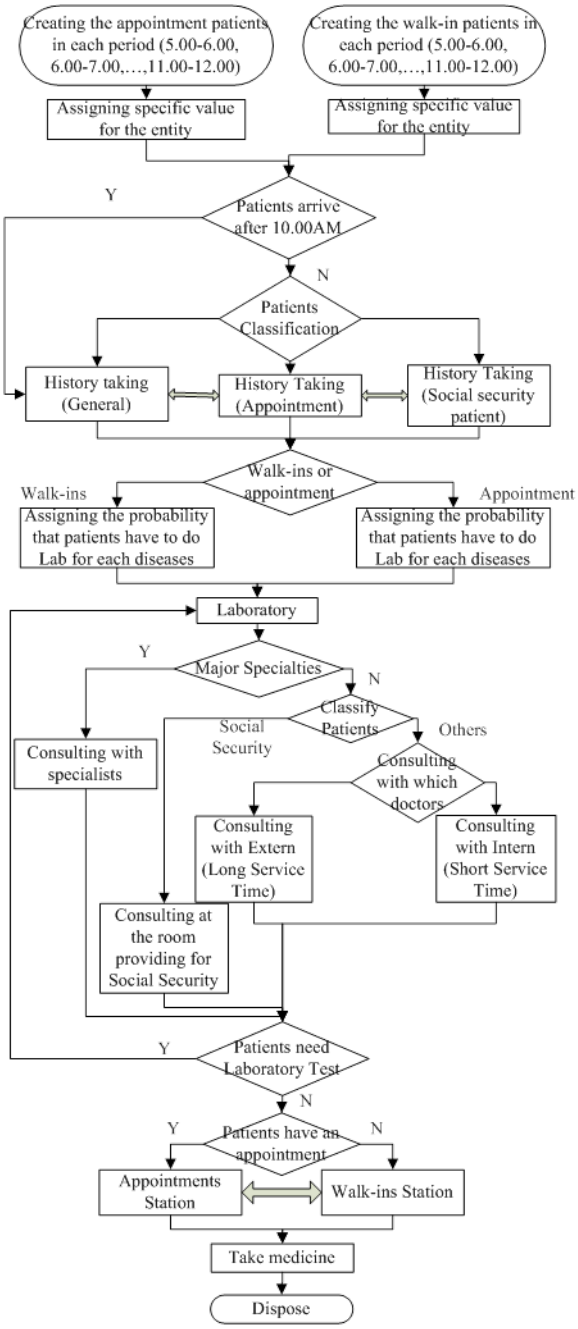

Fig. 9 Arena flow process

V. Verification And Validation

After the model was developed, it was needed to prove the accuracy of the model by verifying the process in the model and comparing the result with the actual data. Since this study's objective is interested in reducing waiting time, the total average waiting times per patient, and the average waiting times at each station are collected to validate the model. The results with 30 replications are taken. The analysis of variance method (ANOVA) is used to examine if the mean waiting times from the model is not different from the actual data. The result shows that mean waiting time is not different, so the model can be used to simulate the outpatient department behaviors.

VI. Experimentation

There is the longest waiting time in front of the consultation room. Our appointment system will focus on appointing patients to meet the doctor. The average waiting times at each station are shown in fig. 10.

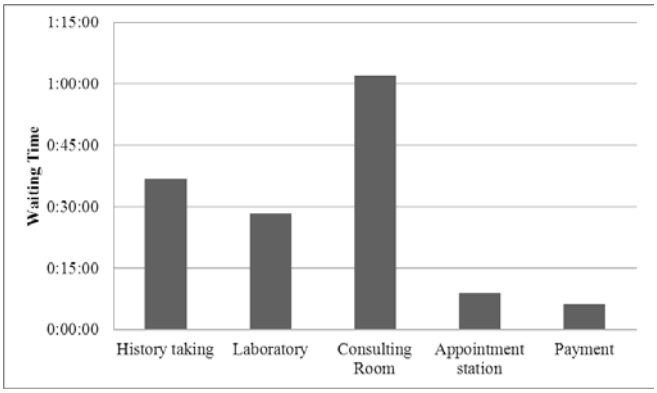

Fig. 10 Waiting time at each station

A. Designing An Appointment System

This research aims to reduce patients' waiting time by applying appointment systems. To implement an appointment system in outpatient department, there are many conditions to be considered. The appointment system performance is always affected by the arrival characteristics of patients. So Patients' unpunctuality, presence of no-shows and walk-ins are included in the system [1]. The same walk-in patients' arrival pattern from as-is simulation model are used to enter to the improvement model. With the difference of arrival characteristics, the queue discipline is needed. In each period of appointment interval, appointment patients have the first priority, unpunctuality patients and no-shows have the same priority with walk-ins in second priority.

Even though we focused on scheduling the patients to consult with doctors, we appoint the patients who need laboratory test roughly 1 hour before the actual consulting time and roughly 30 minutes for the patients who do not need laboratory test. But since several doctors share the same resources at medical history taking stations, it will affect the appointment system [12]; therefore, we will call 2 groups of patients (major specialties and general disease) of the same period to the outpatient department at different times to reduce the congestion at history taking stations. Moreover, sequencing rule which classified patients by processing time (in this case, we defined patients who need laboratory examination to have long processing time) is considered. Reference [10] found that appointing the patients with long processing time to come at the beginning of the session made the appointment system more effective. Therefore, patients who need laboratory examination will come at the beginning of the session.

In this case study clinic, where consultation time is short

and deviate, Individual-block cannot be used. Multiple-block is more appropriate. The Fixed-interval is preferable because it is uncomplicated.

The AS (Appointment Systems) considered in this study is summarized in Table IV. Two intervals are chosen to be tested. There are 4 policies about number of appointments in each interval. As in fig. 8, number of walk-in patients in each period is different. The concept is that number of appointments should be low when there are many walk-in patients in order to reduce patients' waiting times. Therefore, it is another factor to be tested in simulation model.

TABLE IV
APPOINTMENT SYSTEMS

AS	Interval (minutes)	Policy	Equation
1	30	Appointing more patients at the beginning	$n_1^a = n_2 = 0.2N^b$ $n_3 = n_4 = n_5 = n_6 = 0.15N$
2	30	Appointing more patients at the middle	$n_3 = n_4 = 0.2N$ $n_1 = n_2 = n_5 = n_6 = 0.15N$
3	30	Appointing more patients at the end	$n_5 = n_6 = 0.2N$ $n_1 = n_2 = n_3 = n_4 = 0.15N$
4	30	Appointing patients equally	$n_1 = n_2 = n_3 = n_4 = n_5 = n_6 = N/6$
5	60	Appointing more patients at the beginning	$n_1 = 0.4N$ $n_2 = n_3 = 0.3N$
6	60	Appointing more patients at the middle	$n_2 = 0.4N$ $n_1 = n_3 = 0.3N$
7	60	Appointing more patients at the end	$n_3 = 0.4N$ $n_1 = n_2 = 0.3N$
8	60	Appointing patients equally	$n_1 = n_2 = n_3 = N/3$

[a] n_i = number of appointments in interval i
[b] N = number of appointments per clinic session (09.00-12.00 AM)

The results of eight appointment systems are shown in fig. 11. The performance can be measured by the weighted average patients' waiting time and the doctors' over time.

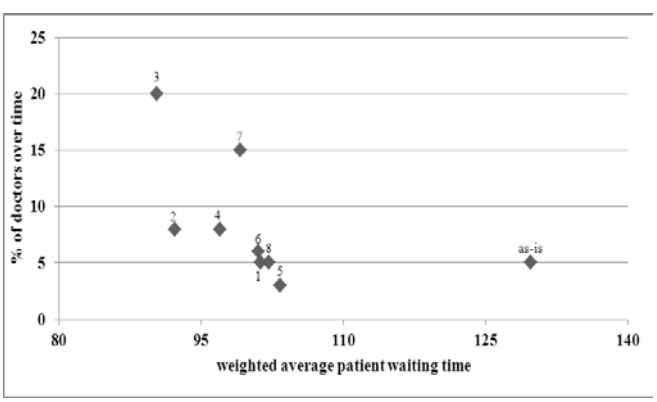

Fig. 11 Appointment system performance

From the scatter plot in fig.11, the appointment system 2 shows the best result due to the short interval which can spread the group of patients. Moreover, number of appointments is related to number of walk-in patients. Appointment system 2 can reduce patients' waiting time by 28.9%, even though it increases 3% (roughly 5 minutes) of doctors' over time.

B. Sensitivity Analysis

In general, there are always patients who come late. This experiment aims to evaluate the appointment system performance if the percentage of patients' lateness is changed. We increased patients with lateness from 10 percent to 20 percent. With more lateness, both patients' waiting time and the doctors' over time were increased. Appointment system with 60 minutes interval seems to be more efficient since the doctors' over time is increased just a little. Appointment system 5 has low of both waiting time and doctors' over time since it provides more patients at the beginning to compensate the ones who do not come and with long interval it has less effect from the lateness. The result is shown in fig. 12.

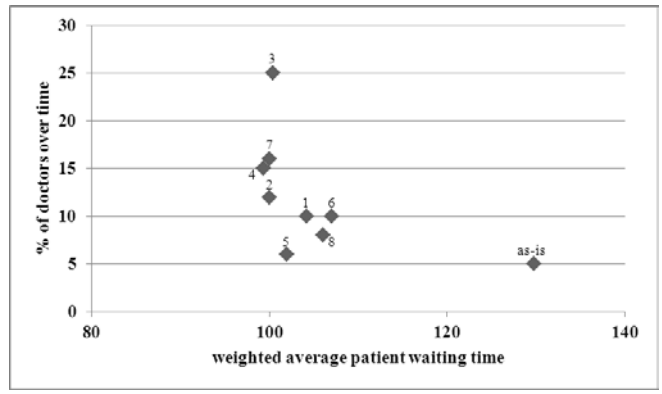

Fig. 12 Lateness sensitivity analysis

To compare the result when the lateness is increased, fig. 13 shows the appointment system 2 and 5 which is the best results from both case. It is obvious that the appointment system 5, which has long interval, is affected by patients' lateness less than appointment system 2.

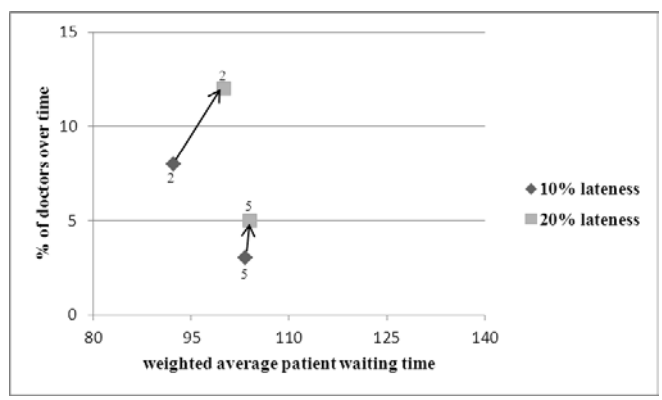

Fig. 13 Comparison between 10% and 20% lateness

VII. Conclusion

In conclusion, the results from simulation model show that an appointment system is an effective solution which can reduce patients' waiting time by 28.9%. In addition, when there is more patients' lateness, a longer interval appointment system is more effective than the shorter interval. In further research, we may consider doctor scheduling to make the balance between number of patients and number of doctors at each period. Moreover, as our case study hospital has many

walk-in patients, we may allow them to make an appointment in order to increase the efficient of the system.

ACKNOWLEDGMENT

The authors would like to thank Thai Health Promotion Foundation who sponsors our research project.

REFERENCES

[1] T. Cayirli and E. Veral, "Outpatient scheduling in health care: A review of literature," Production and Operation Management, vol. 12, no. 4, pp.519-549, 2003. http://dx.doi.org/10.1111/j.1937-5956.2003.tb00218.x

[2] M. Babes and G. V. Sarma, "Out-patient queues at the Ibn-Rochd health center (Book style)," Journal of the Operation Research Society 42 (10), 845-855W.-K. Chen, pp. 123–135, 1991.

[3] T. Cayirli, E. Veral, and H. Rosen, "Designing appointment scheduling systems for ambulatory care services," Health Care Manage Sci, 47-58H. Poor, *An Introduction to Signal Detection and Estimation*, New York, Springer-Verlag, 1985, ch. 4, 2006.

[4] A. Wijewickrama and S. Takakuwa, "Simulation analysis of appointment scheduling in an outpatient department of internal medicine," Winter Simulation Conference, 2005.

[5] M. K. Chung, "Tuning up your patient schedule," Family Practice Management, 41-45, 2002.

[6] R. Fetter and J. Thomson, "Patients' waiting time and doctors' idle time in the outpatient setting," Health Service Research, 66-90, 1966.

[7] J. K. Klassen and R. Yoogalingam, "Appointment system design with interruptions and physician lateness," International Journal of Operation & Production Management, vol. 33, no. 4, pp.394-414, 2013. http://dx.doi.org/10.1108/01443571311307253

[8] N. T. J. Bailey, "A study of queues and appointment systems in hospital out-patient departments, with special reference to waiting-times," Journal of the Royal Statistical Society 14(2), 185-199, 1952.

[9] T. F. Cox, J. F. Birchall, and H. Wong, "Optimizing the queuing system for an ear, nose, and throat outpatient clinic," Journal of Applied Statistics 12, 113-126, 1985. http://dx.doi.org/10.1080/02664768500000017

[10] J. K. Klassen and T. R. Rohleder, "Scheduling outpatient appointments in a dynamic environment," Journal of Operation Management 14, 83-101, 1996. http://dx.doi.org/10.1016/0272-6963(95)00044-5

[11] C. Ho and H. Lau, "Minimizing total cost in scheduling outpatient appointments," Management Science 38, 1750-1764, 1992. http://dx.doi.org/10.1287/mnsc.38.12.1750

[12] N. Yeon, T. Lee, and H. Jang, "Outpatients appointment scheduling with multiple-doctor sharing resources," Winter Simulation Conference, 2010.