Minimizing total waiting time of patients at private healthcare center

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Introduction

Private healthcare centers have become essential part of the health care service in these days. Due the COVID-19 pandemic peoples are not like to wait in long queues at Government or private hospital which are crowded. In private healthcare centers are under a great deal of pressure to reduce cost and improve quality of service which is provided. At present, they are provided greater emphasis on preventive spread of COVID-19.

There are many researchers who study about appointment scheduling. In many literatures, patients' waiting time is a major factor to be considered because it is closely linked with the quality of healthcare centers. The doctor aims to deliver the highest quality of care by reducing the waiting time of each of the patients.

Treatment processing time can be extended according to the age of the patients, type of diseases and the present condition of the diseases. For instance, elderly patients and patients who suffering with chronic diseases are required more attention from the doctor. In this case, there is a one doctor with a large group of patients. Then patients may have to wait more time that they expected. So, they will not satisfy about service with long waiting time.

Therefore, a well-planning schedule for the doctor and patients is important to maintain a satisfied environment. Oppositely, poor planning like a long waiting time for treatment or a high overtime rate for would cause to health deterioration or misdiagnosis. As the doctor would like to quickly finishing his work and so unclear explanation will be happened [3]. Consequently, patients' satisfaction will be decreased. In this situation medical care cost will increased and treatment effectiveness will be decreased. Resources should be well-planned so the private healthcare center will be beneficial.

In this research study purpose a method of Operational Research (OR) to deal with appointment scheduling in private healthcare center. The model for minimize patients waiting time at private healthcare center will be developed and that will be solved with use of LINGO software as a result which will increase the patient satisfaction.

Methodology

Formulate a simple linear programming model for reducing patients' waiting time at private health care center. Some data should be obtained in this research problem. Those are

- Number of patients arrived at one day,
- The arrival time of each of the patient,
- The service duration of each of the patient,
- Total service time of the doctor.

Results and Discussion

Notations. The notations those will be used in model formulation can be explain as follow:

Table 1. Notations and Explanations.

Notation	Explanation	Notation	Explanation
i	Patient ID	W	Total waiting time at consultation room (in minutes)
n	The maximum number of patients	AVG	Average time that takes to get to the pharmacy (in minutes)
DAT	Doctor available time	$PAVT_i$	The arrival time of patient i to the pharmacy
$ARVT_i$	The arrival time of patient i to the Private Healthcare Center	T_i	The arrival time difference of patient i with arrival time of 1st patient to the pharmacy (in minutes)
AT_i	The arrival time difference of patient i with starting consultation time (in minutes)	WE_i	The waiting time of patient i at the pharmacy (in minutes)
WT_i	The waiting time of patient i at consultation room (in minutes)	SMT_i	The time to start taking medication of patient i
SCT_i	The time of starting consultation of patient i	MT_i	The processing time at the pharmacy (in minutes)
PT_i	The processing time of patient i at consultation room (in minutes)	FT_i	The free time of the pharmacist in between patient i and patient (in minutes)
DFT_i	The free time of doctor in between patient i and patient i+1 (in minutes)	M	Total waiting time at the pharmacy (in minutes)
CFT_i	The time that finishing consultation of patient i	LT_i	The leaving time of patient i from Private Healthcare Center

Formulation. By using the notation mentioned above, the new model according to problem description can be formulated as below:

Model-01
Minimize W (1)

Subject to
$WT_1 = 0$ (2)

$AT_2+WT_2=PT_1+DFT_1$
$AT_3+WT_3=\sum_{I=1}^{2}(PT_i+DFT_i)$ (3)
...

$AT_n+WT_n=\sum_{i=1}^{n-1}(PT_i+DFT_i)$

$\sum_{i=1}^{n}PT_i+\sum_{i=1}^{n-1}DFT_i \leq DAT$ (4)

$W= WT_1+WT_2+...+WT_n$ (5)

$WT_i \geq 0$ (6)

$DFT_i \geq 0$ (7)

Model-02
Minimize M (8)
Subject to

$WE_1=0$ (9)

$T_2+WE_2=MT_1+FT_1$

$T_3+WT_3=\sum_{i=1}^{2}(MT_i+FT_i)$ (10)
...

$T_n+WE_n=\sum_{i=1}^{n-1}(MT_i+FT_i)$

$M= WE_1+WE_2+...+WE_n$ (11)

$WE_i \geq 0$ (12)

$FT_i \geq 0$ (13)

Solver introduction. The proposed models for minimize the total waiting time of the patient waiting time at the consultation room and pharmacy of the private healthcare center were solved by using LINGO; The modeling language and optimizer.

Table 2. Hypothetical data set.

Patient ID (i)	Arrival Time (ARVT$_i$)	Processing Time	
		Consultation (PT$_i$)	Medication (MT$_i$)
1	4.00 pm	10	10
2	4.05 pm	08	08
3	4.15 pm	20	07
4	4.30 pm	12	05
5	4.45 pm	30	15
6	4.55 pm	15	06
7	5.10 pm	22	12
8	5.55 pm	18	10
9	6.00 pm	15	09
10	6.40 pm	20	05

Illustrative example. The total waiting time of patients at the consultation room, waiting time of each of the patients and doctors' free time in-between each two consequent patients are calculated by LINGO 11.0 software.

Analysis of the solution. Using the solution which gets from LINGO 11.0 can be obtained following results;

Total waiting time at consultation room (objective value of the model-01) = 88 min.

Total waiting time at pharmacy (objective value of model-02) = 2 min.

Consultation duration = 4.00 pm to 7.00 pm (3 hours).

Medication duration = 4.13 pm to 7.08 pm (2 hours 55 minutes)

Doctor's free time occurred after leaving of 9th patients from consultation room. Number of patients on waiting seat at consultation room and pharmacy when one patient gets consultation or medication also can be evaluated.

Conclusion

In order to maximize patient satisfaction, waiting time plays a significant role in private healthcare center since patients did not interest wait in long queue for get treatment. Therefore, we proposed a model for minimize patients' waiting time depending arrival time of the patients, processing time of the consultation and medication. The proposed model provided global optimum solution. So, the analysed solution be the maximum value for waiting time of each of the patients which cannot increase in same situation according to model formulation. But, considering hypothetical data sets, waiting time at consultation room is increased with number of patients as well as waiting time at pharmacy decreased. Waiting time at consultation room is affected on free time of the doctor. Process of the medication completely depends on process of consultation.

References

[1] Dilrukshi, D., Nirmanamali, I. M., Lanel, G. H. J., Samarakoon, M. A. S. C., A Strategy to reduce the waiting time at the outpatient, Dept. of the N.H in Sri Lanka, March 2016.

[2] Hossain, N. U. I., Debusk, H., Hasan, M. M., Jaradat, R. M., & Khasawneh, M. T., Reducing patient waiting time in an outpatient clinic: A discrete event reducing patient waiting time in an Outpatient clinic: A discrete event simulation (DES) based approach. Industrial and systems engineering conference, 2017.

[3] Lee, C. K. M., Ng, K. K. H., Cheng, M. C., Appointment scheduling optimization for specialist outpatient services. Proceedings of the 2nd European conference on industrial engineering and operations management (IEOM), 2018. pp. 876–883.

[4] Niroumandrad, N.,Scheduling of physicians to minimize patients' waiting time, 2015.

[5] Reenberg, A.,Queueing and Optimization models for hospital patient flow, 2018. pp.1-191.