

Abstract – 015-0191

## **Scheduling Physicians in a University Clinic**

Umar M. Al-Turki  
King Fahd University of Petroleum & Minerals,  
Dhahran, 31261, Saudi Arabia  
[alturki@kfupm.edu.sa](mailto:alturki@kfupm.edu.sa)  
966-3-8602140

POMS 21st Annual Conference  
Vancouver, Canada  
May 7 to May 10, 2010

### **Abstract**

Efficient scheduling of scarce resources is a common need of health institutions, including clinics serving small communities. This study focuses on increasing the utilization of physicians in a small clinic by rescheduling their working hours to meet the daily demand with minimum waiting times, taking into consideration physicians' preferences. A combination of several optimization techniques are deployed to achieve the intended objective including simulation, mathematical modeling and heuristics. Alternative schedules were generated for the management to select from.

### **INTRODUCTION**

Manpower scheduling problem is defined as ‘the problem of optimally matching available labor resources to the needs for labor of an organization considering all applicable constraints’. Another definition for the manpower scheduling is the process by which the daily manpower level for each skill is selected to complete the work in the most efficient (orderly, economical) manner’. So, the purpose of manpower scheduling is to ensure that manpower is working at the time when they are needed and are meeting customer demand for goods or services. It is actually directed linked to the service quality and customer satisfaction.

One of the most important and challenging problems in manpower scheduling is physicians and nurses scheduling in healthcare industry. Hospitals and clinics face real challenge every day to satisfy their customers' needs and their physicians and nurses as well. A comprehensive survey of hospital nurses in five major countries indicated that more than one-third of nurses plan to resign (Aiken et al., 2001). Also, long waiting durations play a major role in determining the service quality level of any hospital or clinic. Long waiting time problems, especially in non profit clinics, can be solved by better scheduling of nurses and physicians to best meet every day demand.

This paper addresses the problem of scheduling physicians in a small size clinic with the objective of increasing efficiency and effectiveness of its operations. The number of physicians at any point time during the official working hours is needed to be at its minimum level keeping a minimum patient waiting time and the quality of service. It was found that major improvement can be obtained by simply revising the working schedule of physicians through out the week to best meet patients demand. Physician satisfaction is also needed to be considered in terms of their working hour preferences for the highest possible service quality.

The main objective of this project is to design a schedule for the doctors to best meet the patients' requirements taking into consideration the management and resources limitations and the doctors' performances. Simulation was used to determine the required number of doctors each hour every day that satisfy a given performance measure. After that, heuristic approaches were used to generate alternative schedules that serve the same objective. Finally, the best schedule was selected and recommendations were developed as well.

The report begins with a brief background about the clinic, its services and facilities. Then, data collection and analysis are described. After that, the simulation model and its use in determining the hourly requirements of doctors are discussed in detail. Based on these requirements, alternative schedules are then described and analyzed. The report ends with recommendations and conclusion.

## **ABOUT THE CLINIC**

The clinic is defined as nonprofit facility organized and operated for the primary purpose of providing outpatient public health services and includes customary related services such as laboratories and treatment rooms. The clinic is dedicated to provide medical care for the university community members including students, faculty, staff and their families. Although there are a lot of specialties in the clinic, the clinic can be divided in two main clinics, general clinic and dental clinic. The general clinic has a total of fourteen physicians and they can be divided into two groups. The first group is the general practitioners and they are ten physicians and the second group, which is the dentists and they are four doctors. The group which is under study in this study is the general practitioners group.

During the regular working days, the clinic opens at 7 A.M and closes at 10 P.M with hour break at 12 P.M for prayer and lunch. In weekends, the clinic opens at 9 A.M and closes at 12 P.M and then opens again at 7 P.M and closes at 10 P.M. Total number of doctors in the general clinic is 10 doctors with different specialties but they are all considered general doctors and can receive any type of patients. In regular working days, Six to seven doctors are available from 7 A.M to 4 P.M. After 4 P.M, once doctor is available until 7 P.M at which another doctor joins him to the end of the working day.

The clinic under consideration is facing problems in serving its patients and satisfying their needs in terms of response time and waiting duration. To improve the situation, we need to analyze the current situation and identify areas of improvement. A possible area could be human resources scheduling. In this project, we will analyze the current practice for scheduling physicians throughout the week. An alternative method will be developed taking into consideration management requirements and staff preferences. Available literature on manpower scheduling will be reviewed from which a suitable method will be selected and used for scheduling physicians in the clinic.

The main objective of this study is to design a new working schedule for the university general clinic physicians that can significantly reduce patients waiting time by best meeting the daily demand taking into consideration the resources limitations and physicians preferences. Such schedule is expected to result in better service quality and higher patient satisfaction.

## **METHODOLOGY**

The methodology adopted in this study is composed of the following steps:

1. Meeting with the clinic director and with university administration to define the problem and specify the needs expressed in measured goals.
2. Reviewing the current practice of staff assignment and scheduling.
3. Collecting data and analyzing it.
4. Developing a simulation model to be used for determining resource (physician) requirement and evaluating different scheduling policies.
5. Constructing alternative schedules for the clinic administration to select from.

## **DATA COLLECTION AND ANALYSIS**

The main source of data related to patient arrival rate was the clinic data base that records the time in which the patient received his admission slip. Arrival rates were noted to be significantly different for different days of the week. In fact, three groups of days were identified; Saturdays and Wednesdays, Sunday, Mondays, and Tuesdays, and Thursdays and Fridays. The differences between arrival rates within each group were not found to be significantly different. Therefore, the collected data were divided into three groups based on the days of the week.

Data were collected for four weeks on hourly bases throughout the full working hours in each group as shown in the tables below. For each hour of the day, the arrival distribution was assumed to follow the Poisson distribution with parameter  $\lambda$ . The assumption was tested using Easy-Fit software and no evidence was found for rejecting the assumption. The value of the parameter was estimated for each hour of the seven weeks to be used in the simulation model.

Service times were collected by directly by observing the time the patient is admitted to the examination room and the time he leaves it. This was done with the help of the staff working in the clinic. Initially collected data did not indicate any significant difference in service time between physicians. So it was decided to combine all data collected from all physicians as a single data set to be analyzed. The data was analyzed for the best fit distribution using Easy-Fit and found to be the Weibull distribution with the parameters  $a=3.7231$  and  $b=9.0772$ . The distribution passed the Chi-square, Kolomogrov-smirnov and Anderson-Darling tests.

### **The Conceptual Model**

Patients arrive to the general clinic every hour in a random manner according to Poisson distribution as described earlier. The patient goes directly to the reception employee to choose an available doctor. After that, he joins a queue and waits until the doctor becomes free to serve him. After being served, the patient goes either to the pharmacy or leaves the system directly. The waiting time is a function of the service time and the queue length. The queue length is inversely related to the number of physicians available in any hour.

### **The Simulation Model**

The objective of the simulation model is first to assess the current situation and then to determine the required number of doctors at each hour that will satisfy a previously defined performance measure. After discussion with the clinic administration and some patients, it was concluded that an average waiting time of ten minutes is a good performance measure. In more formal words, *the performance measure to be used in this project is that the average waiting time for all patients coming at a certain hour should be at most ten minutes.*

As mentioned earlier, Common arrival rates could be used to describe certain set of days. Namely, (Saturday and Wednesday), (Sunday, Monday and Tuesday) and (Thursday and Friday). As a result, three scenarios have to be modeled individually. The three simulation models are almost the same but the only difference is the inter-arrival input data. Visual SLAM (AWESIM) was used to build all the models. The following assumptions were made while building the simulation model.

1. The service time at reception is negligible.
2. Percentage of patients assigned to every physician is the same.
3. Service times for all physicians follow the same distribution.

The model was verified with experts in AWESIM and validated by applying different scenarios for matching expected results. The models output data are the average waiting time in the whole day and the average waiting times for every hour of the day. The models results under the current conditions and scheduling policies are summarized below in figures 1, 2 and 3. Due to the difficulty of collecting actual waiting time data throughout the week, the team collected actual data only to validate the extreme output data. As shown in figure 1, the extreme waiting time data in Saturday and Wednesday are from 5 to 6 P.M with average waiting time ranging from 50 to 70 minutes. Usually no patient waits more than one hour and some get out before he is called. Having this fact in mind, the average waiting data during this period was found to be 58 minutes which supports the validity of the model. The same thing was reported for Sunday, Monday and Tuesday model output data that is shown in figure 2. The actual average waiting time was found to be 47 minutes while the simulation results give a range from 30 to 60 minutes.

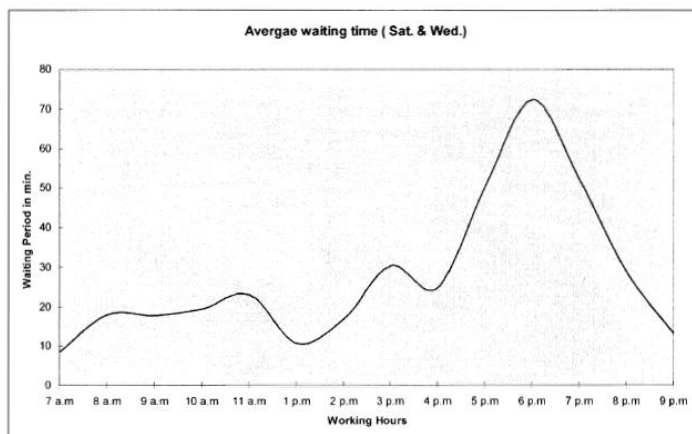


Figure 1. Average waiting times for Saturdays and Wednesdays

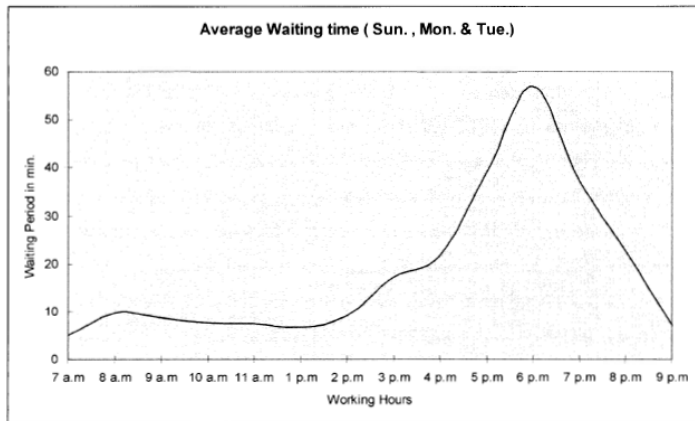


Figure 2. Average waiting times for Sundays, Mondays and Tuesdays

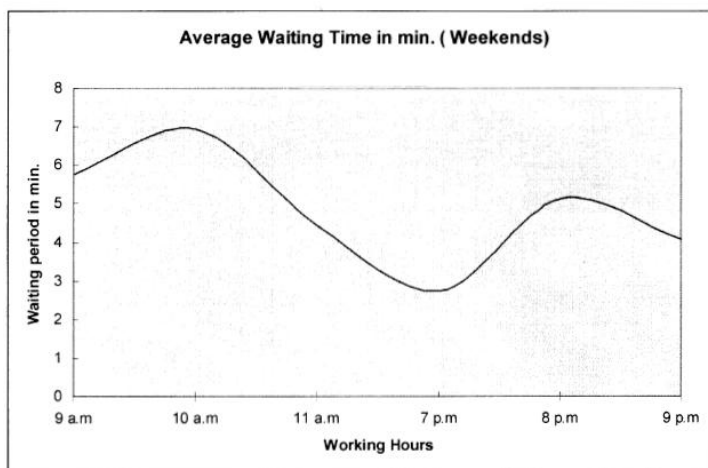


Figure 3. Average waiting times for Thursdays and Fridays

The model is a terminating scenario since the clinic is closed at 10 P.M and no entity is allowed to come in after that event. The number of runs for each simulation model was determined using the t-test with 95% confidence level. The number of runs for Saturday and Wednesday group was found to be 110 runs and 50 runs for the remaining working days. For the week-ends (Thursdays and Fridays) 20 runs were found to sufficient for 95% confidence level.

### Physicians Required

The model is used to determine the number of physicians needed at any hour of the week that would result in an average waiting time of less than ten minutes as determined by the clinic administration. Table 1 shows the number of physicians and the average waiting time for the whole week.

Time	Saturday & Wednesday		Sunday-Tuesday		Thursday & Friday	
	Physicians	Average waiting time	Physicians	Average waiting time	Physicians	Average waiting time
7	5	8	4	7.9		
8	7	9.6	6	9.3		
9	5	10.6	4	9.8	2	6.3
10	7	9.5	5	9.3	2	6.8
11	6	9.1	4	10.1	2	3.8
13	5	9.6	4	9.7		
14	6	9.5	5	7.5		
15	6	11.2	5	10.6		
16	2	5	2	4.2		
17	2	7.7	2	6.7		
18	2	7	2	5.4		
19	3	6	2	5.1	2	2.4
20	2	8.9	2	4.5	2	2.7
21	2	12	2	4.5	2	2.331

Table 1. The minimum number of physicians needed and the average waiting time

Clearly it is not practical to have an hourly schedule for the physicians to meet the requirement. Table 1 is to be used for constructing a shift schedule that fits the requirement. This task is done in the next chapter.

### **Shift Scheduling**

Manpower scheduling is a wide area of research where different tools are used to find optimal or near optimal schedules. Mathematical modeling is widely used for solving such problems, but due to the complexity of the problem, heuristics and metaheuristics are commonly used in the literature. In this study, we preferred to use the manual shift scheduling heuristic (MSSH) that was developed by Bechtold and Showalter (1987). The selection was made based on the simplicity of the heuristic and its effectiveness.

Three scheduling policies are chosen for the sake of comparison and for the administration to select the most suitable and most desirable by the physicians.

Alternative 1: three shift policy

In this alternative three shift schedules are adopted with one hour break each. The three shifts are:

Shift A: from 7 AM to 4 PM (break from 12 to 1 PM)

Shift B: from 10 AM to 7 PM (break from 12 to 1 PM)

Shift C: from 1 PM to 10 PM (break from 6 to 7 PM)

The MSSH heuristic resulted in assigning seven physicians in shift A, two in shift B and three in shift C. This means that we need twelve physicians to satisfy the requirement while there are only ten physicians available. To fix the schedule to satisfy the available manpower, we need to remove two physicians from the schedule in a way that will have the least effect on the requirement. The schedule is then

adjusted to have 6 physicians for Shift A, 2 for Shift B and 2 for Shift C. As a result, the minimum requirements for all hours are satisfied with the exception of the 8 AM and 7 PM hours.

Similar procedure is applied for the remaining three days of the week resulting an assignment of 6 physicians for Shift A, 2 for Shift B and 2 for Shift C which satisfies the hourly requirement and matches the available manpower. Furthermore it is the structured shifts for the other two days. Therefore there will be need to change the shift structure through out the week days.

For the week-end, only two physicians are needed in two shifts to satisfy the requirement. The resulting assignment for the whole week is shown in Table 2.

Shifts	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
A	6	6	6	6	6	2	2
B	2	2	2	2	2	0	0
C	2	2	2	2	2	2	2

Table 2. Shift structure for the whole week.

The resulting schedule will assign the ten physicians to the three shifts in the weekdays while the week-end is covered by overtime shifts rotated between the physicians.

The developed schedule has two major drawbacks. The first is the shortage of manpower in two hours of the day resulting from the adjustment made in the original shift structure. The second drawback is the inefficient distribution of the physicians throughout the day. The two drawbacks will result an increase in the waiting time in two hours and very short waiting time in the remaining hours, which may be considered is low utilization of resources. To reduce this problem the schedule is further modified as follows. One of the physicians in shift B will be assigned to a

special two half shifts per day (8 AM to 12 PM then 6 PM to 10PM) and one from shift A will be assigned to a two half shifts (7 AM to 12 PM then 7 PM to 10 PM).

The result is more efficient schedule with no shortage in manpower.

Alternative schedules

Other alternative schedules are currently under construction.

### **Conclusions**

The scheduling problem of physicians in a medium size university clinic is considered. The objective is to produce an efficient schedule that satisfy the patient's need of short waiting times and give alternative schedules for physicians in satisfying the duties. Simulation is used for evaluating alternative shift schedules as well as assessing the current situations. The study is not yet complete as the work on developing more alternative schedule is underway.

### **Acknowledgment**

The author acknowledges King Fahd University of Petroleum and Minerals for supporting this study.

### **References**