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Multi-Criteria Decision Making in Outpatient Appointment Scheduling: An Application

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Abstract— In this paper, an optimization scheme is proposed in order to scheme the patient appointment at SEY-MET Dental Polyclinic and to reduce the effect of the No-Show patient rate. In order to provide an efficient performance for the SEY-MET Polyclinic in the long term, a new appointment system is established. In this context, the improvement model considers factors which found to influence patient scheduling decisions in outpatient clinics. A simulation model is developed to determine the optimum appointment system, Response Surface Methodology (RSM) was used to set the optimum availability factor and Goal Programming (GP) method are constructed to determine the available weekly appointment for each service room.

Index Terms— Healthcare Optimization, Scheduling, Simulation, Goal Programming, RSM.

1 Introduction

Basically, the outpatient centers represent a key interface in a patient's progress from primary care to specialist services. Also, it has been one of the pressing areas that need to be more organized. To serve the patients in an effective manner, the reorganization of present health care systems is essential. Primarily, the multi objective appointment scheduling system for outpatient polyclinics developers in the patient flow process for the patient registration to the doctor or nurse assignment is a crucial part. Furthermore, monitoring and reviewing patient's system and also taking into account that the health care systems have been challenged in recent years, to deliver high quality healthcare with limited resources.

There are some important researches about scheduling systems improvement techniques, especially by simulation optimization and goal programming techniques. Among them, Ercan's [4] mathematical model, which is focused on minimizing the investment budget, maximizing the efficiency of technological designs, and also minimizing the operational costs, in the energy industry, is exists. Self-organizing maps (SOM) were clustered to observe the frequency of subjects analyzed and scheduling optimization in his study.

The focus of this article is on appointment scheduling in healthcare. Thus, it is not considered the questions pertaining to the size of facilities, equipment and administrative staff. Mainly, patients are defined as the customers of health care services. The satisfaction of the patient is also vital to get success. The measures of quality are listed as; affordability, waiting time and coordination of care [16]. Waiting time, in particular, is the most common subject of complaint among patients. For a wide knowledge, especially about appointment scheduling in healthcare, Çayırlı and Veral made a review article [3]. Consequently, the main purpose of this work is to accommodate variable patient demand and conditions and to allow patients to be served as close as possible to appointment time.

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Some alternative models for operational decisions was suggested to improve the appointment scheduling, the assignment of patients according to their priority and to construct a scheduling assignment model. Health systems in most countries aim to provide a comprehensive range of services to the entire population and to ensure that standards of quality, equity and responsiveness are maintained. Regarding decision making, hospital management has a different focus due to their emphasis on resource, process or financial management in the context of the external hospital environment and this focus is identified in the hospital mission. As well as resource management plays a key role in most hospitals. Actually, there are many researchers who study about appointment system and they extract that the effective appointment system can increase doctors utilization and also reduce patients waiting times. In addition, research on outpatient clinics shows that waiting times are patient's main dissatisfaction with hospital services. Moreover, the outpatient system was examined and used a predictive analytics, optimization, and overbooking to schedule outpatient appointments in the presence of no-shows. The problem of optimal overbooking appointments was tackled and given no-show predictions that depend on the individual appointment characteristics and on the appointed day to maximizing the number of patients seen while minimizing waiting time and overtime [13]. Additionally, Vahid and Torresb [11] presents a predictive model to be used in scheduling patients in an urban outpatient clinic. Decision tree analysis was used to develop a model that assessed the likelihood of a patient's no-show. Kachhal [9] distributed the workload of an audiologist uniformly in an ear, nose, and throat outpatient clinic by dividing the non-ear patients and ear patients between two doctors. They managed to reduce the average waiting time by 44.7 % in this study. Harper and Gamlin [7] developed an algorithm that distributed appointments over the whole clinic session. Güler [5] scheduled the assignments of the residents and the senior academic staff to outpatient clinics in a physical medicine and rehabilitation department. He proposes a hierarchical goal programming model to address these issues. Finally, there are various approaches to solve the appointment scheduling problems. An overview of commonly used techniques is given in the next section.

2 EXPERIMENTAL WORK

For the importance of the subject, it is aimed to optimize the appointment system in a dental polyclinic, by the scope of knowledge and scientific methods.

2.1 Factors Affecting In the Dental Polyclinic Centers

In the Dental Polyclinic improvement model, multiple criteria are to be considered when allocating resources to different departments. These decision criteria include: utilization rate, waiting time for patients, total time staying in polyclinic for patients, the number of patients every specific period and the workday duration of polyclinic. SEY-MET Dental Polyclinic was chosen as an implementation center for this study. Like many other facilities, there is a need to optimize its use of resources, to make a drastic study to allocate its resources and to achieve a qualified improvement scheduling system in the service rooms. These critical decisions generally have been studied in this work with the support of simulation, GP and RSM models, which are routinely used in other service industries. The aim of the model is to determine the impact of factors on the system and to help identifying an appointment scheduling process to use existing resources more efficiently and effectively. In the following sections, it is deliberated over the procedure and methods for applying an improvement appointment scheduling system.

2.2 Basic Concepts of SEY-MET Polyclinic System

SEY-MET Dental Polyclinic is physically made up of many different service rooms and waiting area. The polyclinic serves patients who have teeth diseases, especially who lives in Etlik /Ankara. The staff; dentists, nurses and administrative staff in the polyclinic, have different responsibilities. In the polyclinic, there are three general dentists that have same specializations and four specialist dentists. In most situations, new patients see one of the available general dentist and returning patients see either the general dentist or the specific one. Generally, the patient either confirms with the appointment, or reschedules a new appointment in the reception department. In general, patients need to make an appointment before visiting the polyclinic. Patients arrive to the polyclinic and check-in if they have an appointment or not. According to collected data, 51.34% of patients have a scheduled appointment before their coming.

2.3 Fitting the Statistical Distribution of Parameters

A family of distributions is selected based on the context of the input variable according to the shape of the histogram. The samples that selected to present service time of patients for both walk-in and scheduled are collected in the seven service room in SEY-MET Dental Polyclinic. Easy-Fit Program is used to accomplish this step which allows fitting probability distributions to sample, data selects the best model, applies the analysis results to make better decisions and conducts hypothesis testing on input samples using Kolmogorov-Smirnov and Chi-square tests. For the selected samples a significance level of 0.05 is used to make the hypothesis testing for Easy-Fit tests. The information about the distribution types for the collected data to all service rooms is summarized in Table 1 and Table 2. The table also includes the parameters of the distribution of all service rooms in the SEY-MET dental polyclinic.

TABLE 1
DISTRIBUTION TYPES AND PARAMETERS FOR TIME BETWEEN ARRIVALS FOR THE DIFFERENT DEPARTMENTS

No.	Department	Distribution Type	Distribution Parameters
1	Orthodontics	Uniform	a= 11.786 b= 102.96
2	Prosthesis	Normal	σ=35.096 μ=72
3	Surgery	Uniform	a=55.688 b=106.0
4	Children	Normal	σ=35.781 μ=85.294
5	General 1	Weibull	α=1.9144 ß=66.973
6	General 2	Weibull	α=2.5941 ß=94.113
7	General 3	Weibull	α=2.1039 ß=90.67

TABLE 2
DISTRIBUTION TYPES AND PARAMETERS FOR ARRIVAL TIME FOR THE DIFFERENT DEPARTMENTS

No.	Department	Distribution Type	Distribution Parameters
1	Orthodontics	Normal	σ =21.484 μ=67.765
2	Prosthesis	Log-normal	σ =0.26529 μ=4.0725
3	Surgery	Log-normal	σ =0.2138 μ=4.4918
4	Children	Triangular	m=40.0 a=19.121 b=82.647
5	General 1	Triangular	m= 39.0 a= 0.04043 b= 85.314
6	General 2	Log-normal	σ=0.34207 μ=3.8386
7	General 3	Normal	σ =16.205 μ=40.313

2.4 Simulation Model

In this study, after the data is collected and analyzed, the simulation model is built in Arena Version 14th as a discrete-event, stochastic model. The model runs for one week (7days) every day except Sunday from 09:00 to 22:00 and on Sundays from 11:00 to 20:00, or when all patients are served to the last patient. SEY-MET polyclinic work 13 hours every day with different work period for the staff. SEY-MET simulation model is divided into three sections: The first section is for the walk-in patients who came to the polyclinic without an appointment, the second section is for the general scheduled patients who make an appointment at the general department dentists, which represents all the process of the general patients in the dental polyclinic and the third section for scheduled specialist patients. The simulation model is run for 52 replications to show the system behavior annually. Banks. J. [2] Determine whether Simulation of the model is a credible representation of a real system, as an aid in the validation process. In this research, a statistical test of the null hypothesis is conducted to test the validation as shown in table 3.

TABLE 3

VALIDATING INPUT-OUTPUT TRANSFORMATION

Statistical Terminology	Modeling Terminology	Associated Risk
Type I: rejecting H_0 when H_0 is true	Rejecting a valid model	A
Type II: failure to reject H_0 when H_0 is false	Failure to reject an invalid model	B

The output of the model is calculated for 52 replications, and the average number of the actual output for 52 weeks (29.58 weekly appointments) is calculated. Z = 29.58 weekly appointments, the model responses, Y. Formally, a statistical test of the null hypothesis is conducted:

H_0: E(Y) = 29.58 weekly appointments

H_1: E(Y) ≠ 29.58 weekly appointments

For the dental appointment model a level of significance α= 0.05, and a sample size n =52 is chosen. Based on the preceding researches, the appropriate is noticed to be from t- student two-sided test. H_0 is not rejected and thus concludes that the model is adequate in its prediction of the average weekly appointments.

2.5 RSM for a Multi-Objective Optimization System

RSM consists of a group of mathematical and statistical techniques used in the development of an adequate functional relationship between a response of interest y and a number of associated control (or input) variables. In SEY-MET appointment system RSM Box-Behnken designs (BBD) is used to inactivate the optimum availability factor which can improve the system and reduce the daily variable cost. The determined factors during the response in this experiment is the daily variable cost, the goal is to minimize the response. Four process parameters in the SEY-MET system may affect the response. Table 4 shows these factors and their levels.

TABLE 4

RSM FACTORS AND LEVELS

Factor	Name	Unit	Level 1	C. Point	Level 2
A	Utilization Rate	%	40	60	80
B	Serviced Patient	Patient	32	37	42
C	Workday Duration	Minutes	720	750	780
D	Waiting Time	Minutes	15	40	65

Because there are less than five factors, a full factorial design was used in order to screen significant factors. 24 designs with four center points were chosen to check the possible curvature. A 27- randomized run BBD with four center points is conducted. DOE++ 10 software is used to create a Box-Behnken design. The following steps were used to build and use RSM:

[1] Identifying Significant Effects: After performing the randomized runs in the displayed order and recording the results, the data are entered as set in the DOE++ 10 software. The data set will be analyzed using the significance level of 0.1. In addition, the test statistic for the effects will be calculated using the partial sum of squares as shown in the ANOVA table will show the results for each individual term. In order to see which effects are significant, Table 5 shows an ANOVA table which contains the detailed summary of results was examined. According to it, the effects A, B, C, D are significant. And the p value for A.B is close to the risk level 0.1. Therefore, these factors will also be included in the final model.

TABLE 5

RSM MODEL ANOVA TABLE

ANOVA Table					
Source of Variation	Degrees of Freedom	Sum of Squares [Partial]	Mean Squares [Partial]	F Ratio	P Value
Model	14	1.083408E+6	77386.25728	23.994757	0.000001
A:Utilization Rate	1	861352.0833	861352.0833	267.07499	1.452892E-9
B:Serviced Patients	1	66156.75	66156.75	20.512882	0.000691
C:Workday Duration	1	101568	101568	31.492665	0.000114
D:Waiting Time	1	25576.33333	25576.33333	7.930322	0.015573
A • B	1	9025	9025	2.798335	0.12021
A • C	1	930.25	930.25	0.288438	0.60104
A • D	1	2916	2916	0.904149	0.360431
B • C	1	5700.25	5700.25	1.767447	0.208419
B • D	1	1	1	0.00031	0.98624
C • D	1	225	225	0.069765	0.796161
A • A	1	3663.342593	3663.342593	1.135874	0.3075
B • B	1	178.898148	178.898148	0.05547	0.817776
C • C	1	4131.703704	4131.703704	1.281096	0.279807
D • D	1	219.592593	219.592593	0.068088	0.798566
Residual	12	38701.58333	3225.131944		
Lack of Fit	10	31592.91667	3159.291667	0.888856	0.637503
Pure Error	2	7108.666667	3554.333333		
Total	26	1.122109E+6			

[2] Optimization Model: In this step, the model is calculated after only the effect significant is selected. The coefficients for the parameters in the optimization model as shown in table 6 and table 7.

TABLE 6

REDUCED MODEL ANOVA TABLE

ANOVA Table					
Source of Variation	Degrees of Freedom	Sum of Squares [Partial]	Mean Squares [Partial]	F Ratio	P Value
Model	5	1.063678E+6	212735.6333	76.456793	9.415266E-13
A:Utilization Rate	1	861352.0833	861352.0833	309.568346	4.783011E-14
B:Serviced Patients	1	66156.75	66156.75	23.776614	0.00008
C:Workday Duration	1	101568	101568	36.503351	0.000005
D:Waiting Time	1	25576.33333	25576.33333	9.192087	0.006342
A • B	1	9025	9025	3.243568	0.086084
Residual	21	58431.01852	2782.429453		
Lack of Fit	19	51322.35185	2701.176413	0.759967	0.708392
Pure Error	2	7108.666667	3554.333333		
Total	26	1.122109E+6			

TABLE 7

REDUCED MODEL REGRESSION INFORMATION

Regression Information						
Term	Coefficient	Standard Error	Low Confidence	High Confidence	T Value	P Value
Intercept	3799.259259	10.1515	3781.79114	3816.727379	374.255966	0
A:Utilization Rate	267.916667	15.227249	241.714487	294.118846	17.594554	4.785061E-14
B:Serviced Patients	74.25	15.227249	48.04782	100.45218	4.876127	0.00008
C:Workday Duration	92	15.227249	65.79782	118.20218	6.0418	0.000005
D:Waiting Time	46.166667	15.227249	19.964487	72.368846	3.031845	0.006342
A • B	-47.5	26.374369	-92.883506	-2.116494	-1.800991	0.086084

This model will be used as the final model to conduct optimization. This means that, the following setting is used to create an optimal solution plot in an optimization model.

The vertical blue line in the Pareto Charts-Regression plot in Figure 1 marks the critical value determined by the risk level. If the bar goes past the blue line, then the effect is considered significant. From these results, the significant effects A, B, C, D and A.B will be included in the model indicate that these are significant.

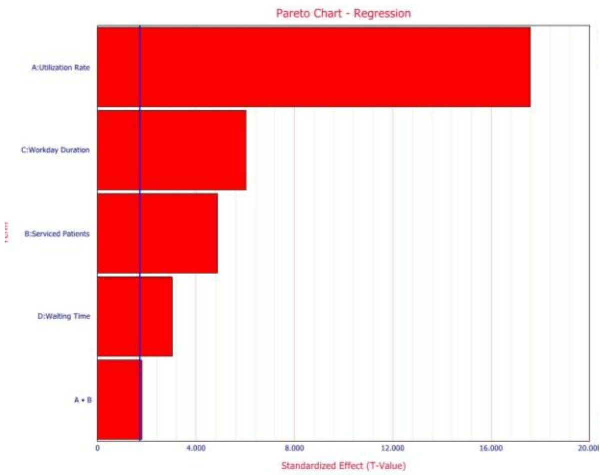

Fig. 1. Pareto Chart- Regression

Figure 2 is the corresponding graphs of the affected factors for SEY-MET dental system. In these figures, the value of the optimum availability factor can be set easily.

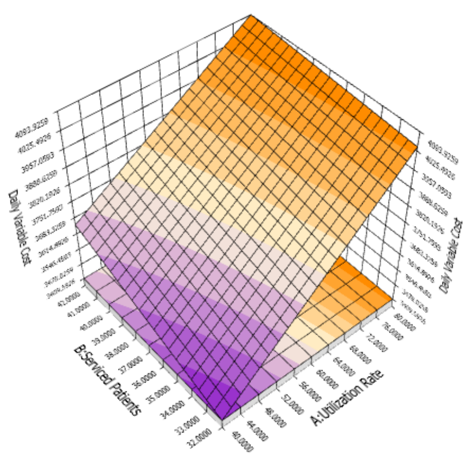

Fig. 2. RSM surface Plot

2.5.1 Conclusions of the RSM Model:

RSM provides statistically-validated predictive models that can then be manipulated for finding optimal process configurations. The end result of applying these statistical tools for design and analysis of experiments in the SEY-MET dental polyclinic will be in specification results that exhibit minimal variability the ultimate objective of robust design. Figure 3 shows the best setting factors are found to be A = 40%, B = 32 patients, C = 720 minutes and D = 15 minutes. The experiment plans to conduct an experiment using these settings to confirm this conclusion.

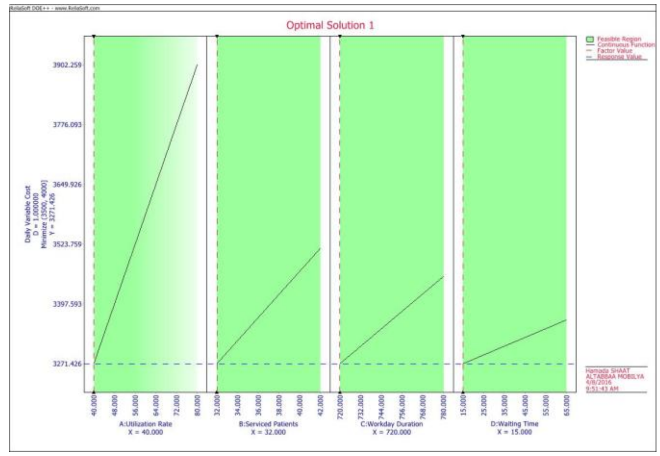

Fig. 3. Optimal BBD result

2.6 Goal Programming Model for Appointment System

The analytic hierarchy process (AHP) has found widespread application in decision making problems, involving multiple criteria in systems of many levels [12]. This method has the ability to structure complex, multi-person, multi attribute, and multi-period problem hierarchically [19]. AHP can be very useful in involving several decision-makers with different conflicting objectives to arrive at a consensus decision [17]. SEY-MET appointment model is built using the weighted sum method as recommended and selected parameters. The weights after the AHP method was applied are identified as shown in Figure 4. This was used to determine the objective function of the GP model.

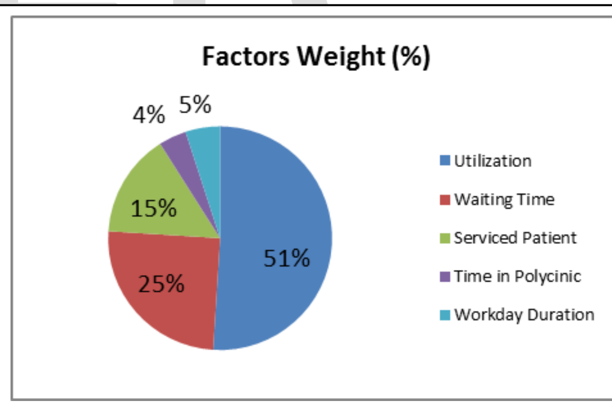

Fig. 4. SEY-MET Polyclinic Factors weight

The decision maker of SEY-MET wants to give five primary factors. In particular, management has established the goals of (1) achieving utilization rate at least 40% for both general dentist and prosthesis dentist and 80% for surgery and orthodontics, (2) patients waiting time must not exceed 30 minutes, (3) total time in polyclinic for the patient must not exceed 90 minutes for general patient and 120 for specific patients, (4) weekly total of serviced patients at least 24 patients for both general, 4 for surgery and 13 for prosthetic dentist and (5) Workday duration not exceed 780 minutes. Let X1, X2,…. X7 be the number of allowed appointment for each service room in the polyclinic. The combined objective function (1):

$$\text{Min } 51 S^-_1 + 25 S^+_2 + 14 S^-_3 + 4 S^+_4 + 5 S^+_5 \qquad (1)$$

The constraints below show the minimum and maximum values of allowed appointment for the general and the specialist dentist which was identified by observing the change in the value of the criteria according to simulation result and SEY-MET managers.

$24 \le X_1 \le 72$	General 1 Constrains	(2)
$24 \le X_2 \le 72$	General 2 Constrains	(3)
$24 \le X_3 \le 72$	General 3 Constrains	(4)
$24 \le X_4 \le 72$	Children Constrains	(5)
$8 \le X_5 \le 24$	Orthodontics Constrains	(6)
$24 \le X_6 \le 54$	Prosthesis Constrains	(7)
$3 \le X_7 \le 9$	Surgery Constrains	(8)

These constraints are derived from the regression of each criterion vs. weekly available appointment curves. Constraint 9 and 10 are for the average utilization criterion for the general departments, and specialist departments respectively, while constraines 11 to 17 are for waiting time, general sized patients, surgery seized patients, orthodontics sized patients, average total time in polyclinic for general patients, average total time in polyclinic for specialist patients, workday duration criteria respectively.

$$0.266 X_1 + 0.270 X_2 + 0.238 X_3 + 0.252 X_4 + 0.293 X_6 + 3.075 + S_1^- - S_1^+ = 40 \qquad (9)$$

$$1.515 X_5 + 4.736 X_7 + 6.598 + S_1^- - S_1^+ = 80 \qquad (10)$$

$$0.134 X_1 + 0.131 X_2 + 0.183 X_3 + 0.201 X_4 + 0.511 X_5 + 0.253 X_6 + 0.631 X_7 + 19.34 + S_2^- - S_2^+ = 30 \qquad (11)$$

$$0.146 X_1 + 0.155 X_2 + 0.165 X_3 + 0.165 X_4 + 0.152 X_6 + 3.892 + S_3^- - S_3^+ = 24 \qquad (12)$$

$$0.857 X_7 + 0.286 + S_3^- - S_3^+ = 4 \qquad (13)$$

$$0.858 X_5 + 0.489 + S_3^- - S_3^+ = 13 \qquad (14)$$

$$0.821 X_1 + 0.259 X_2 + 0.226 X_3 + 0.246 X_4 + 0.477 X_6 + 14.41 + S_4^- - S_4^+ = 90 \qquad (15)$$

$$0.487 X_5 + 1.687 X_7 + 26.28 + S_4^- - S_4^+ = 120 \qquad (16)$$

$$0.586 X_1 + 0.480 X_2 + 0.338 X_3 + 0.393 X_4 + 0.567 X_5 + 0.964 X_6 + 1.796 X_7 + 585.170 + S_5^- - S_5^+ = 780 \qquad (17)$$

All these constraints are put in the LINDO solving program to obtain variable values for this model and the results are discussed in the next section.

3 Experimental Design

In this section the experimental results of the suitable methods to solve the problem and improve the system will be discussed.

3.1 Simulation Application

In the simulation model, every arriving patient see just one of the general or specialist dentist at each appointment. SEY-MET manager notice that the no-show rate for the returning scheduled patients who are served by the general dentists is higher than the patients who is served by specialist dentists. So, we should focus on changing the parameters of the returning scheduled patients who are served by the general dentists. In particular, we can change the expected time between arrival for patients who are served the general dentists as 20, 30, 45, 60, 75 and 90 minutes. For each interval of the time between arrival of patients who are served by the general dentists, we again change the expected time between arrival for patients who are served by a specialist dentist as 30, 45, 60, 75 and 90 minutes. For further explanation of these comparisons, let T_1 = the time between arrival for a returning scheduled patients who are served by one of the general dentists, and T_0 = the time between arrival for a returning scheduled patient who are served by one of the specialist dentists. And by changing T_1, the value of each factor for every level of T_0 is calculated from the simulation model. The simulation results show that when the time between arrival decreases, the total number of served patients increases, the utilization of staff increases and the patient waiting time increases. So, we need to show the trade-off between the waiting time and utilization. Table 8 is compiled to study the tradeoff between the utilization rate and the waiting time. Our goal is to choose a set of parameter settings that yields higher utilization and shorter waiting time. In addition, it is targeted that the workday duration be near 13 hours (9 am to 10 pm) or 780 minutes. Table 8 suggests that the combination of the time between arrival for general patients being 45 minutes and the time between arrivals for the specialist patients being 60 minutes meets our criteria. Particularly, for this setting, the average utilization is 40%, the average waiting time is 13.78 minutes, the average total time for patients in clinic is 64.73 minutes (1.08 hours), the number of patients served for each general dentist per week is 34, and duration of the clinic workday is 702.8 minutes (11.70 hours). In addition, it's noticed that there are linear relations between the number of available weekly appointments and utilization percentage, waiting time, number of serviced patients, the average time in polyclinic and the workday duration. This means that, increasing the number of available weekly appointments has positively impacted on the criteria, the increasing of the number of appointments affects the selected criteria positively. This is the aim of this study to maximize the utilization and the number of serviced patient, and to minimize the waiting time, total time in polyclinic for scheduled patients and the workday duration.

3.2 Goal Programming Application

In the goal programming model, depending on the output of AHP methods that are used as input of goal programming model, the constraints and objective are set and then the result is calculated using LINDO which gives the optimum available appointment for each dentist. Table 9 shows the optimum available appointments in SEY-MET Polyclinic. This output shows that the largest number of appointments is in the children's department because of the high arrival rate for this department.

As indicated in this study, the improvement model takes into account the time between arrival and time distributions for the department in order to optimize the appointments distribution to satisfy Polyclinic management goals for the five main criteria.

TABLE 8
THE RESULT OF THE SIMULATION MODEL

No.	T_1	T_0	Utilization Rate (%)	Waiting Time for Patients (min.)	# of serviced Patients	Total time in Polyclinic (min.)	Workday Duration (min.)
1	20	30	0.47	37.47	53	83.51	800.91
		45	0.46	28.63	48	79.41	792.24
		60	0.44	27.05	52	72.72	764.97
		75	0.43	22.52	50	64.65	755.88
		90	0.41	17.93	49	59.1	721.54
2	30	30	0.45	34.86	38	79.2	780.31
		45	0.42	29.43	38	68.64	752.39
		60	0.39	25.96	37	68.3	738.27
		75	0.38	14.93	37	63.22	719.67
		90	0.37	9.36	36	56.47	701.53
3	45	30	0.43	22.75	37	72.54	762.93
		45	0.42	19.37	35	64.01	735.84
		60	0.40	13.78	34	64.73	702.8
		75	0.39	7.53	30	60.4	687.73
		90	0.38	5.47	27	54.01	668.37
4	60	30	0.34	24.41	31	65.75	756.73
		45	0.33	19.84	28	58.64	718.54
		60	0.32	17.43	28	57.66	687.88
		75	0.3	8.25	27	54.75	672.7
		90	0.29	4.86	26	48.74	645.82
5	75	30	0.33	31.05	29	57.87	725.58
		45	0.32	27.83	29	51.9	684.49
		60	0.29	19.95	27	48.18	669.42
		75	0.28	15.58	26	46.18	652.89
		90	0.27	9.47	26	42.79	615.94
6	90	30	0.28	6.03	24	51.4	704.65
		45	0.27	4.54	22	46.85	664.7
		60	0.26	3.66	21	42.78	658.92
		75	0.25	2.55	21	41.34	647.56
		90	0.25	1.08	20	39.86	587.97

TABLE 9
THE RESULT OF THE OR MODEL

No.	Variable	Variable Name	Value
1	X_1	Number of weekly allowed appointment for General dentist 1	47
2	X_2	Number of weekly allowed appointment for General dentist 2	42
3	X_3	Number of weekly allowed appointment for General dentist 3	41
4	X_4	Number of weekly allowed appointment for Children's dentist	51
5	X_5	Number of weekly allowed appointment for Orthodontic	23
6	X_6	Number of weekly allowed appointment for Protez	42
7	X_7	Number of weekly allowed appointment for Surgery	9

4 CONCLUSIONS

In this research, the SEY-MET dental polyclinic center in Ankara, Turkey is simulated. The actual model is formulated and supplied with Arena 14 software. The model is verified and validated after many suggestions of experts in this field of study and by using hypothesis technics. All the guidelines and details to make a successful simulation model are followed. Many schedules are suggested by varying the appointments system for both general and specialist service rooms. It is found that no appointment system dominated any other system relating to all performance measures. In consequence, the model for different suggested period is preceded, and the best appointment system among the generated alternatives according to the simulation model is selected. It is found that the best schedule that can be used in the polyclinic is the system which gives a new available appointment every 45 minutes for the general patients and a new available appointment every 60 minutes for the specialist patients. Response surface methods

(RSM) are used as a powerful optimization tool in the statistical design of experiments (DOE). This method generates a response surface map to show and to move the process to inactivate the optimum availability factor which can improve the system and reduce the daily variable cost. Finally, A Goal programming approach is implemented to select the available weekly appointment for each service room.

As a consequence, this type of modelling could be applied to outpatient departments operating with multi doctor, and a static appointment system. In this research, the dentists are considered as the only resource that provides services. This modelling approach could be extended to schedule more resources such as nurses and laboratory practitioners.

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