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Simulation Modeling for Process Improvement in a General Surgery Service

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Abstract: The aim of the study is to improve the General Surgery patients' treatment duration in order to eliminate the bottlenecks by speeding up the process. For this purpose, some model proposals were carried out to allow reorganizing the processes to serve more patients by improving the productivity of the clinic. The study has been carried out in the general surgery clinic at the well known, training and research hospital. First of all, the simulation model of the existing system was demonstrated. The simulation model has been developed via PROMODEL software program. In the simulation model installed, four scenarios have been established in order to determine the critical factors which effect patients' waiting durations. Thus, the goal of the study was to reduce the waiting times by considering what-if analysis using simulation. The model has been worked on for six months and ten times repetitively, so to get some statistics. It has been determined that an improvement of 17% efficiency of operations in clinic may be considerable in case of reviewing and redesigning the processes of the General Surgery clinic. It was found that a decrease of 76, 57 and 52% in the duration patients' being in the system for Medical Treatment (MTP), Operation (OP), and Urgent Operations (UOP), respectively. All outcomes of study showed that an improvement in the efficiency could be acquired without any financial burden for the hospital budget by enhancing the processes in General Surgery clinic via using simulation modeling.

Key words: Hospital, process improvement, simulation, waiting duration

INTRODUCTION

Making the patients wait for any reason in the phase of diagnosis and treatment is the biggest cost vice versa the geometrically accelerating technological improvement nowadays. On one hand, the patients waiting duration for the treatment causes a progression for their disease, on the other hand, it leads to the increment of social and economic burden. Reducing patients' waiting times is the responsibility of managers, and there well will be several solution options to choose. As all of these optional choices would lead a cost, it may not be estimated as appropriate goals and objectives determined. Simulation technique refers to completing the processes of revised procedures, carrying out the trials and estimating the error times of the processes. With this method, new process designs' possible reactions to changes could be learned. There are many solutions for the problem related to waiting durations in hospitals as the options are increasing physical spaces, increasing the number of man power, changing the shape of quality and work, and lastly new equipment and equipment supply.

Before making a choice, working processes should be analyzed and reviewed as to identify the factors of patients' length of stay and decrease of patient circulation time. Reducing the patient duration has become important as to serve more patients while having the same existing resources and number of beds (Esatoglu and Bozat, 2002). Health investments and workforce planning are expensive investments which require more resources. For this reason it is obvious that the solution can't be tested by different choices of trials. Objective information is required in order to estimate the desired outcomes. So, an approach is needed to estimate the possible errors or possible results.

This study is about organizing the hospital to work more efficiently with current limited number of beds. In the study, a simulation model was demonstrated to decrease the patients waiting durations via improving the processes and some suggestions were evolved in a training and research hospital.

Simulation: It may be possible to provide more service for more patients with current number of beds by hospital management benefiting from scientific methods. System analysis is one of the scientific approaches for health managers to consider in decision-making. This approach is a technique which examines the interaction and solutions for the issue systematically (Checkland, 1998). The system analysis which is an effective and useful technique considering executive decision making requires a certain process monitoring and decision making method. The system analysis approach is a technique directed to determine and assess the system researches related to a

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new system design or existing systems and the results of different action options which exist in the system or could be proposed (Checkland, 1998). Another method used in executive decision making process in hospitals is simulation model applications addressed with the system analysis. Benefiting from simulation methods, the design and planning of the resources is to form them with the optimum components by determining bottlenecks of the hospital system.

Simulation modeling is an ongoing process of understanding the behavior of the system or running experiments to evaluate different strategies due to purpose of operating the existing system. The simulation methods allow acquiring the experience in a safe environment which can only be available after real experiences and real faults in long term (Harrel *et al*., 2000). The simulation model of a system is the process of forming a model which is able to represent the existing system and to transfer the situations from real life to the computer interfaces. The simulation modeling allows user to derive and repeat the attitudes of decision issues which are difficult, time consuming and expensive to experience under physical conditions, and to pick the best alternative amongst alternative models for the operators (Anderson *et al*., 2000).

Simulation modeling is used in management problems such as low productivity and low quality as their dynamic and resistant nature (Barlas and Diker, 2000). Simulation modeling is a tool which perfectly fits for complex systems after creating a good representation of the existing system via feedback, observation and patience. It has advantages like a factory's new facility or a supermarket's new supply chain, without investing much and testing it without taking any risks, watching the customers in a queue of a banking system and system variables effect. Simulation is basically used to identify where the system "exploded". Simulation modeling is an indispensable tool in systems improvement based large-scale studies. Vice versa simulation modeling also has some disadvantages. Simulation itself is a province, takes a lot of time to learn and master. For this reason, the experts may charge a high price because of the information required for a chaotic system. However, running the simulations may take a lot of time and simulation may response slow when urgent responses are required (Barlas, 2007).

Use of simulation in health services: The health sector is a typical area in which rapid changes are experienced. So the health institutions try to find out the needed materials and methods in order to improve their ability to follow those changes up (Barnes *et al*., 1997). In our country like other countries, the requirement of efficient and productive utilization of the resources is brought forward because of the technological progress, increased lifetime, increased costs of health services considering differentiated disease patterns and urbanization (Belek, 2001). The hospitals, providing second and third line health services which use the major part of the resources, efficient and productive usage of resources is one of the first significant precaution to be taken (Sur, 2009).

First simulation modeling applications in health care administration were used in modeling hospital systems. Fetter and Thompson (1965) carried out the first hospital simulation applications in Grace-New Haven Community hospital, and they tried to form hospital administration policies by providing alternatives through determination of hospital bed and other resources. Smith and Solomon (1966) tried to develop hospital administration policies to enhance hospital utilization rates based on acquired statistical distributions as a result of the examination of patient admission rates monthly, using a simulation method in Lexington U.S. Public Health Service. Uyeno (1974) focused mostly on human resources management and planned in terms of occupational groups and abilities of the staff in order to decline patients' waiting durations. Frieberg (1981) used the simulation method for improving marketing strategies considering estimation and simulation tools in order to develop marketing strategies and systematical plans for hospital use.

Simulation technique was used in many of health services in an up scaling fashion. Baesler and Sepulveda (2001) have determined four different targets related to the system and developed the model aiming to find the most convenient combination of present control variables in their simulation study in a cancer treatment center in 2001. They have compared the solution options which were formed for four targets, and determined an enhancement between 18 and 25% depending on the situation. In a study by Pulat *et al*. (2001), it has been interested in the primary care bed needs in the state of Oklahoma. Their study aimed at the generation of the best-case scenario for primary care service delivery. Also one of the main objectives of this study was to estimate the expected number of primary care beds needed in each service area under the assumed patient inflow rate and length of stay days. Simulation model was established for these purposes. A simulation model of the system was used to determine the minimum number of primary care beds needed in the state to provide service at targeted service levels at these centers. They had the use of ARENA and SIMAN for simulation application. By Çetinsaya *et al*. (2004), work processes were redesigned, patients' duration in the system was decreased by combining pay desk and appointment processes in a public hospital in Turkey, so the utilization of the pay desk has been increased. Therefore it has been determined that the wasted time by doctors was prevented because of the improvement in flow rate because of the pay desk to the examination. White (2005) has performed a simulation

for work flows including patient admission, discharge, diagnosis-treatment, patient stay term, and number of patients who stay in hospital and emergency services. In that study input analysis explaining the variables have been carried out and model data has been obtained. Its results allow using alternative resources to determine the direction of ambulance flow rates as per the number of the patients in those regions which need urgent responds particularly. Kumari and Shim (2005), in his study using simulation model, has reported the simulation to be helpful to make the optimization of human resource use in hospital and distribution process of surgery materials in the hospital more efficiently, and it could be used for also other similar processes. It has been determined that in China the long waiting durations in patient admission lines in especially large hospitals cause a lot of wasted time for patients because of the population density. Su and Yao (2006) have analyzed work flows and process terms by using a simulation model. They have redesigned the processes via simulation and compared with different approaches in order to decrease the lines. As a result of the study average admission time was decreased from 17.24 to 3.15 min, so the optimum admission rate has been obtained.

In a study by Taaffe *et al*. (2006), the evacuation of the hospital has been simulated in case of a disaster which was a non-predictable and complex process. The study emphasizing the importance of an evacuation plan for the acts of God has demonstrated the success rate of the evacuation plans to be related to the alternative plans forming substantially different scenario and resources. Department performance and capacity plan have been developed by a simulation model in a study in which patients waiting lists in Halifax Hospital Surgery Clinic in Canada Nova Scota have been analyzed by Vanberkel and Blake (2007). Different combination options have been formed by determining independent variables which affect patient stay terms via models formed with present and additional resources, it has been found that the number of beds to be increased in order to decline waiting durations. In another study by Cipriano *et al*. (2007) in Ontario it has been found that patient waiting durations for knee and hip prosthesis operations were more than six months, and those waiting periods effects the post-operative recovery negatively. In the study the number of surgeons and the patient rates from the region has been found inconsistent. It has been found when increasing the number of surgeons by 12% that waiting durations would be decreased within ten years, and efficient distribution and waiting durations in every regions would be decreased further.

In a study by Duguay and Chetouane (2007), it has been described a discrete event simulation study of an emergency department at Dr. Georges- L. Dumont Hospital in Moncton, Canada. In their study the emergency department was modeled, analyzed and improved using discrete simulation. An analysis of waiting times by patient codes demonstrated high waiting times in comparison with Canadian standards. The objective of the study was to reduce patients' waiting times and to improve overall service delivery and system throughput by considering what-if analysis using simulation. As patient waiting times are linked to resource availability, a number of alternatives were designed based on adding resource scenarios. Model development was made using Arena software. Simulation showed that waiting duration from registration to available exam room was the most problematical. Their methodology was based on considering physicians, nurses, and examination rooms as control variables. Five alternatives were formulated based on adding staff and exam rooms within budget limitation. Each alternative was simulated for each day using ten replications of 12-h lengths. Simulation showed that number of examination rooms had no effect on waiting time if added without a matching increase in the staff. It also showed that significant waiting time is not caused by exam room shortage as suspected initially by the management team.

The hospitals, providing second and third line health services which use the major part of the resources, efficient and productive usage of resources is one of the first significant precaution to be taken. Hospitals having the existing number of beds providing service for more patients may be possible with using scientific methods with more economic and scientific conditions by the hospital management (Yigit and Agırbas, 2004). It should be determined why the waiting queues of patients get longer and where the system hitches. The answer for the increment of waiting queue should be found out. Do the units work less or are the number of patients is increasing. Simulation technique can be used in reducing patient waiting times and identification of bottlenecks in the system, as well as creating options in order to find out effective solutions. Thus, the problem will be determined and also a planning will be available for the issue to be solved.

GENERAL SURGERY CLINIC APPLICATION

Objective and targets of the study: The study was carried out in general surgery clinic of a training and research hospital. The aim of the study is to improve the General Surgery patients' treatment duration in order to eliminate the bottlenecks by speeding up the process. For this purpose, some model proposals were carried out to allow reorganizing the processes to serve more patients by improving the productivity of the clinic. Thus some model proposals were carried out to allow reorganizing the processes. The goals of the study are given below:

- To analyze system and working processes
- To decrease patients' waiting durations

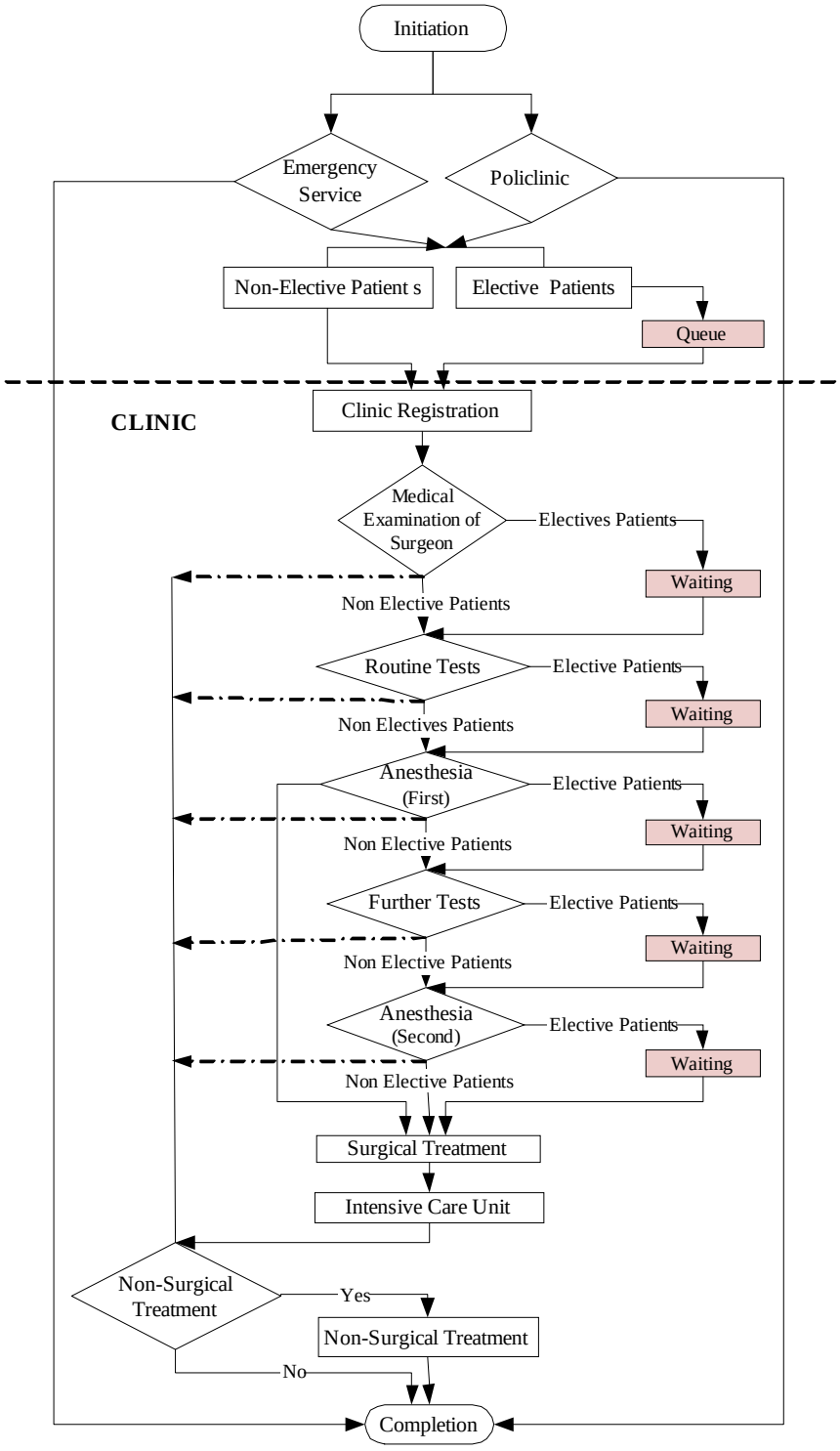

Fig. 1: Working process of system

- To increase patients' circulation by decreasing patients' duration of stay in clinic
- To increase the overall number of patients served

Method and simulation processes: In order to execute the objective of the study the simulation method was considered. First of all, the simulation model of the

existing system was demonstrated. The simulation model has been developed via a package program, PROMODEL. On the simulation model installed, four scenarios have been established in order to determine critical factors which effects patients' waiting durations. Thus, the goal of the study was to reduce waiting times by considering what-if analysis using simulation. The model has been worked on for six months and ten times repetitively, so some statistics have been acquired.

In the built simulation model, all of the processes for General Surgery patients applied to the hospital were considered beginning from their entry to the system and their exit from the system. In order to decline applied capacity plans and patients' waiting durations a simulation model was executed in the General Surgery Clinic. The algorithm below was followed in the application period of the simulation model. This algorithm comprises the definition of the problem, compiling and processing the data, specifying the model, forming the computer program, verifying the model logic, compatibility of the model with the real system, planning scenarios, and analysis of the outputs, respectively.

1st Step: Detailed examination and design of the present system.
2nd Step: Description of the factors and characteristics forming the system
3rd Step: Determination of present patient and work flows in the system
4th Step: Examination of the process terms and description of the statistical distributions in the system
5th Step: Installation and operation of the system on PROMODEL software
6th Step: Verification of the validation and outputs of the system
7th Step: Execution of the scenarios
8th Step: Analysis of the outputs

Examination of the system and definition of the working processes (Step 1-2): The patients check into the general surgery clinic in two ways, through polyclinic and emergency service. A specialist in the general surgery clinic enrolls the patients who need to stay in hospital for the patient group recommended by the polyclinic to rest. Patient stays is carried out as per that list. A triage is applied to the patients in the general surgery clinic according to their emergency and surgical treatment priorities.

Needed examination and therapies for an inpatient are planned. According to the (pre)diagnose for the patient some blood and urine samples are taken, and sent to the laboratory. Besides radiological and advanced radiological test requests are stated by the doctor, and those tests are executed in the hospital.

Considering the definition of the work processes first all of the processes beginning from their admission to discharge were examined. The processes that the general surgery patients experienced in the hospital start first with the emergency service or polyclinic, and after the laboratory in which the tests are performed, radiology, advanced radiology, anesthesia and surgical treatment processes, and postoperative care, the clinic and hospital term is accomplished by the patient to be discharged. Present work processes of the hospital are shown in Fig. 1.

Definition of the patient groups (Step 3): After examining the work processes of the general surgery patients, at this stage, patient definitions occurred after the processes were examined. First patients in the system are defined as "Emergency Patient-Non-elective Patient" and "Non-Emergency Patient-Elective Patient". Inpatients are described again after their tests and examinations as tree types of patients. Those are "Non-Surgical Treatment Patients (NSTP)"; "Surgical Treatment Patients (STP)" and "Urgent Surgical Treatment Patients (USTP).

NSTP are inpatients and discharged patients after a treatment. STP are patients on which it's decided to a surgical operation for their treatment. Those patients are assessed by an anesthetist as per the operation type before the operation, and consequent to the examination it's decided to a surgical treatment. Patients who experienced an operation are discharged arranging their treatment after they receive a postoperative medical care. USTP are the patients with priority, and they need to stay immediately in hospital without any waiting and at every o'clock of the day, and to be treated. Those patients are taken in immediately, and their need of surgical treatment or non-surgical treatment is executed quickly, and then they are discharged. The process for NSTP and AH is worked in five days of the week and in working hours. However when continuing NSTP and STP patients' processes in the clinic in case of the time goes on and the working hours are ended, other processes such as operating room is operated also until the process is over. Considering USTP, every processes are executed without any waiting also in weekends and holiday at every o'clock of the day. In Table 1, according to patient types the steps of the process and actions of patient are given.

Determined as to be used for surgery primarily, some situations reduce the efficient use of projected patient beds. The first one of these situations is that the routine, or as a result of further investigations or reviews by anesthesiologists, surgeons conclusion as the surgery is not necessary. In this situation, patients are discharged without any surgical procedure. The second one of these situations, the cause of this is, the patients whom waiting for preoperative preparation , have had to be made further routine and advanced examinations by the

Table 1: Steps of the process and actions of patient

Patient	Place	Function	Event			Conclusion
Admission	Emergency service	Medical examination of patient and assessment	Initiation		Completion	• Hospitalization • Discharge
	Policlinic	Medical examination of patient and assessment	Initiation	Waiting	Completion	• Hospitalization • Discharge
	Out of the hospital	Waiting		Waiting		• Hospitalization • Other hospitals etc.
Non-elective patients	Clinic/ Service	Medical examination and assessment of Surgeon	Initiation of medical examination		Completion	• Surgical treatment
		Routine tests and assessment: Radiology, blood and urine tests	Initiation of tests		Completion	• Surgical treatment • Further tests • Discharge [Operation(-)]
		Medical examination and assessment of anesthetist	Initiation of medical examination		Completion	• Surgical treatment • Discharge [Operation(-)]
		Further tests and assessment: Hormone, nuclear medicine, MR, BT, markers and tissue tests etc.	Initiation of further tests		Completion	• Surgical treatment • Discharge [Operation(-)]
		Medical examination of anesthetist	Initiation of medical examination		Completion	• Surgical treatment • Discharge [Operation(-)]
		Surgical treatment	Initiation of surgical treatment		Completion	• Intensive care unit • Non-surgical treatment • Discharge/Re-process
		Intensive care unit and assessment	Initiation		Completion	• Non-surgical treatment • Discharge/Re-process
		Non-surgical treatment and assessment	Initiation	Observation	Completion	• Discharge/Re-process
Elective patients	Clinic/Service	Medical examination and assessment of surgeon	Initiation of medical examination		Completion	• Surgical treatment • Discharge [Operation(-)]
		Medical examination and assessment of anesthetist	Initiation of medical examination	Waiting	Completion	• Surgical treatment • Discharge [Operation(-)]
		Routine tests and assessment: Radiology, blood and urine tests	Initiation of tests	Waiting	Completion	• Surgical treatment • Further tests • Discharge [Operation(-)]
		Further tests and assessment: Hormone, nuclear medicine, MR, BT, markers and tissue tests etc.	Initiation of further tests	Waiting	Completion	• Surgical treatment • Discharge [Operation(-)]
		Surgical treatment	Initiation of surgical treatment		Completion	• Intensive care unit • Non-surgical treatment • Discharge/Re-process
		Intensive care unit	Initiation		Completion	• Non-surgical treatment • Discharge/Re-process
		Non-surgical treatment	Initiation	Observation	Completion	• Discharge/Re-process

anesthesiologists and doctors in order to make assessments about their conditions. These patients are decided to have surgery in according to the results of pre-operative preparation done as mentioned. No surgical procedure is done to this patient group until the decision will be made whether they will be surgical treatment or not. The third of the situations is that reduces the efficiency usage of bed, whom need inpatient treatment after a surgery and are to be examined. There is another patient group that also uses the existing limited number of patient beds due to preventable causes such as infection or complication after the completion of their surgeries. All these three conditions reduce the speed of bed rotation and increase the day number of the patients' inpatient treatment. These two have a negative impact on the productivity of bed usage. With the help of re-planning processes, it is thought to that the bed usage productivity will be positively affected.

General surgery clinic data (Step 4): After describing work processes and patient groups the data defining general surgery clinic and process were examined. In this way how much time did the patients pass for this processes, the number and rates of admission and discharge, and the transition rates of the triage between those processes were determined. In order to determine the admission rates of the general surgery patients and the time spent by the patients for working processes 800 patients' file dated between January-July 2008 were inquired in electronically patient record medium. As per

Table 2: Number of inpatients in general surgery clinic (January-June 2008)

Months	NSTP	STP	USTP	Total
January	31	55	40	126
February	30	68	33	131
March	34	46	43	123
April	21	57	41	119
May	32	52	36	120
June	31	59	38	128
Total	179 24%	337 45%	231 31%	747 100%

Table 2, 747 inpatients have been treated in first six months of 2008. The patients consisted of NSTP 179 (24%), STP 337 (45%), USTP 231 (31%). The general surgery clinic has 39 beds, and 3 operating rooms amongst 16 have been allocating for the surgery clinics. Besides one more operating room has been allocating for only urgent cases.

Waiting duration of the patient for the admission in the clinic was found as tree months in average. Those patients need some laboratory and screening tests after the admission, and every test group requires a certain time. Test durations for small surgeries is around one day, and the patient is operated next day. But medium and large scaled operations need a lot more preparation time. Especially the patients with goiter and gall bladder and some patients with carcinoma wait two days in average for the test results, and they wait for advanced radiology tests tree days in average. After completing every tests including anesthesia consultation the patients are operated in the day after (next day). Surgical operation time is two hours in average, and postoperative stay in the service was found as one day.

Installation of the simulation model (Step 5): The simulation model was installed via a package program, PROMODEL. In the study the waiting durations caused by various reasons in non-surgical treatment and non-surgical treatment times for inpatients were determined for those processes, and the reasons of the determined waiting durations were stated, so the options to reach the solutions considering those determined reasons were acquired using the simulation model.

On the simulation model installed various scenarios were established in order to determine critical factors which effects patients' waiting durations. The performance criteria are stated as follows.

- Number of patients
- Number of patients came from polyclinic
- Number of patients came from emergency service
- Operating room performance: number of patients operated.
- Number of patients discharged
- Time spent by patients in system

Formed scenarios (Step 6-7): In the study three variables were considered, treatment for the patients, and preoperative preparation procedures plan; declared number of operating rooms and beds, and test times including work flow plans groups. In the study four scenarios were formed in order to derive potential solution proposals which may be constituted by every one of those variables.

Scenario-1: The capacity of the operating room was increased with 33%. The improvement on the capacity was provided by adding an operating room to the single operating room.

Scenario-2: Increasing the bed capacity with 50%, a bed capacity of 60 beds was provided.

Scenario-3: The working hour for the operating room was increased with 50%. The working ours are between 08:30 and 16:30, but considering the scenario the ending time was stated as 20:30.

Scenario-4: The test durations were removed. Because it depends on the base of performing the biochemical, radiology, and advanced tests before the patients' admission, test durations for this scenario was taken as zero.

First three of the four scenarios formed needs some investment, and the fourth requires the redesigning of the work processes. The Scenario-1 requires an additional operating room, so some location, equipment and additional labor are needed. The Scenario-2 requires at least 10 rooms, 20 beds and its equipments and labor. The Scenario-3 requires an improvement and reorganization for hospital offering by increasing working hours. In case of executing those three scenarios an economical burden seems to be added to the hospital budget. And the Scenario-4 was designed based on some changes in hospital work processes. In this scope the biochemistry, radiology, and advanced test processes were considered, and the tests in the scenario were formed by assuming them to be executed before the admission. The Scenario-4 was prepared in order to inquire whether any productivity acquisition could be obtained by enhancing only the processes, without any financial burden for the hospital budget differently from the other scenarios.

Simulation application and scenario analysis (Step 8): The model was being operated for six months between May 2009 and October 2009. The time that the system was operated with all of its factors, "warm up" time was found as 1438 h (2 months). The system outputs were considered after the "warm up" term. The model was operated for six months and ten times repetitively (replication), so some statistics were acquired. The simulation moment display of the general surgery clinic of the training and research hospital on March 30, 2009 is shown in Fig. 2.

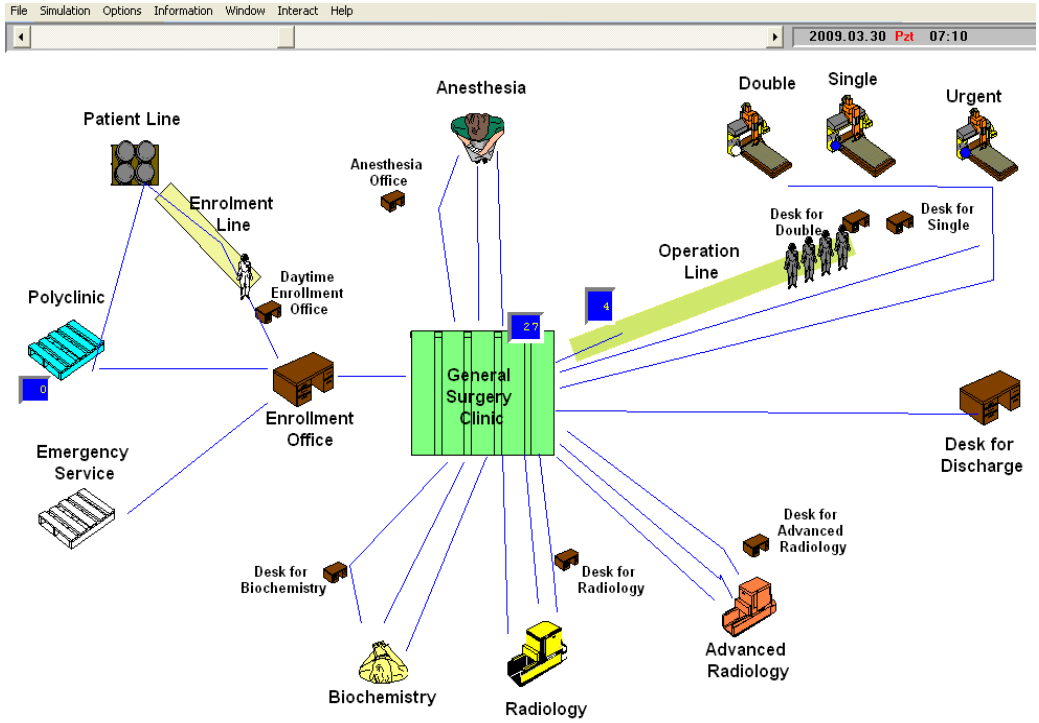

Fig. 2: Simulation moment display

Table 3: Scenario results in terms of arrival numbers of patients arrival

Number of patients	Scenario-1	Scenario-2	Scenario-3	Scenario-4
Number of inpatients	915	870	908	877
Coming from policlinic	658	646	656	651
Coming from emergency service	257	224	252	226

Table 4: Number of operations in operating rooms

No. of patients	Scenario-1	Scenario-2	Scenario-3	Scenario-4
No. of patients operated - double	252	248	263	273
No. of patients operated - single	212	195	194	174
Total	464	443	457	447

FINDINGS

Simulation modeling results are evaluated according to the previously given data.

Terms of arrival numbers of patients' arrival: The number of the patients came to the general surgery clinic and processed in the clinic are shown in Table 3. In Scenario-1, in six months of time, the number of patients came to clinic is 915. 658 of them came from polyclinic and 257 of them arrived from emergency service. According to Scenario-2, the total number of patients is 870 and according to Scenario-3, the number is 908 and in Scenario-4 it is found as 877.

As given in Fig. 3; some increase on the number of patients came to the service and processed in the service considered in the scenarios was found. According to this result, when increasing 33% the number of the operating rooms (Scenario-1) causes an increase of 23% on the number of inpatients in the process of the general surgery clinic, when increasing the number of beds with 50% (Scenario-2) it causes an increase of 17%, when increasing working hours with 50% (Scenario-3) it causes an increase of 22%, and when removing test durations (Scenario-4) it causes an increase of 18%.

In terms of operating room performance: Scenario results of surgeries made in operation room is given in Table 4. According to Scenario-1, in six months of time, it is recorded 464 number of patients operated. 252 of 464 are in operated in double room and 212 of them operated in single operating room. According to Scenario-2 total number of patients operated is 443 and in Scenario-3 it is 457 and lastly in Scenario-4 it is found as 447.

As given in Fig. 4; there has been an increase over operating rooms' performance. According to this result,

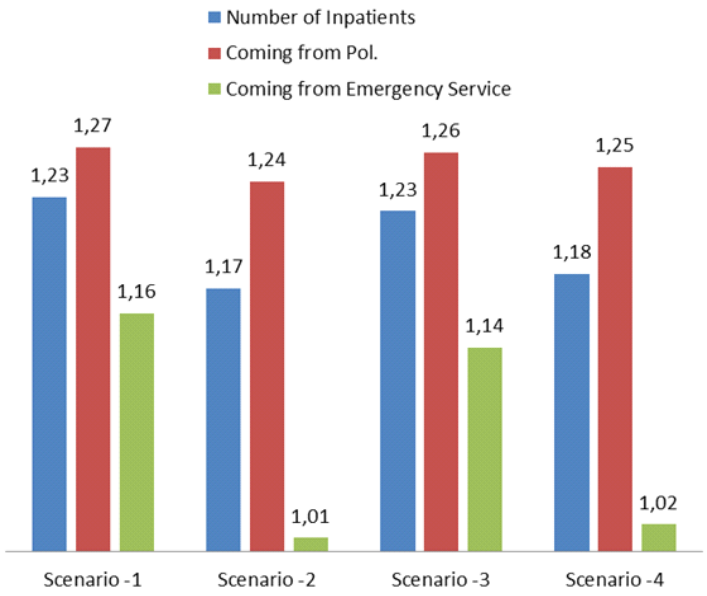

Fig. 3: Number of incoming patients' rate of change

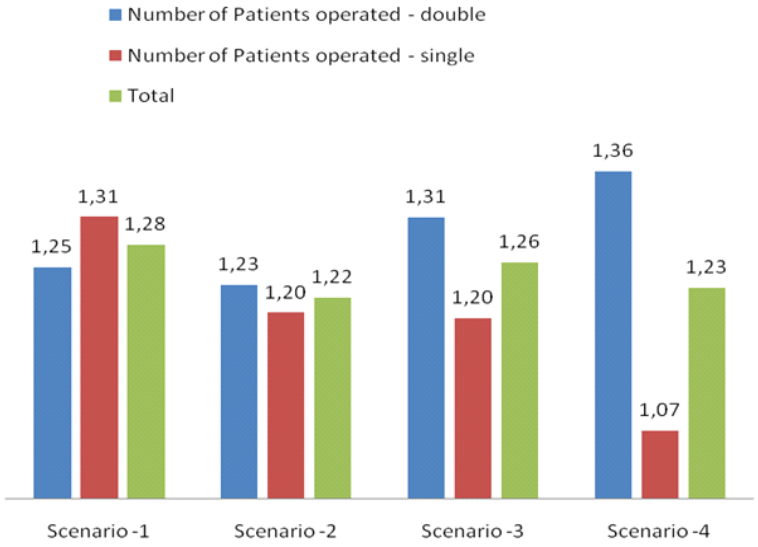

Fig. 4: Change of operations' rate in operating rooms

increasing the number of operating rooms by 33% (Scenario-1) makes a positive impact as the growth of patients operated in the number of 25%. When this number is 50% as mentioned Scenario-2 this number is 23%. And according to Scenario-3, increasing the total daily work time by 50% it causes an increment of 31% and according to Scenario-4 when the examination times of patients are removed from the system it is recorded a 36% of improvement.

In terms of discharged patients from the system: As mentioned in method section, the patients in the general surgery clinic are evaluated in tree groups. As given in Table 5, total number of non surgical treatment patients (NSTP) was found as 183, number of surgical treatment patients (STP) found as 261, number of surgical treatment patients (USTP) was found as 264, and total number of all patients was found as 908 in six months of time.

Table 5: Scenario results in terms of patient class

Patient groups	Scenario-1	Scenario-2	Scenario-3	Scenario-4
NSTP	183	185	187	190
STP	464	443	454	448
USTP	261	242	262	235
Total	908	870	903	873

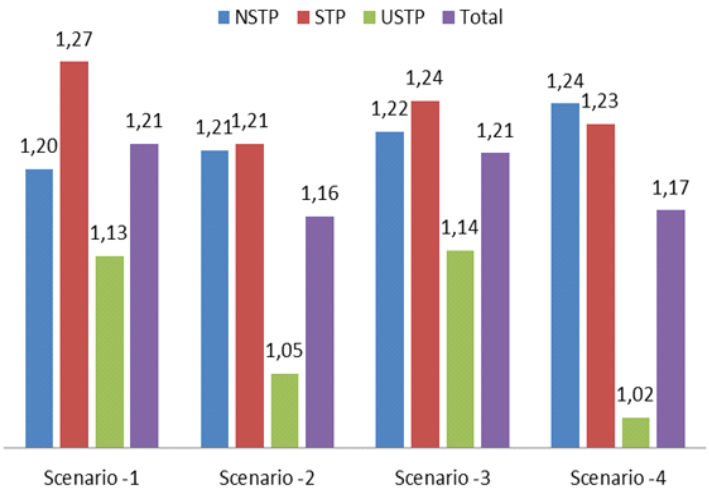

Fig. 5: Patient numbers in terms of patient class

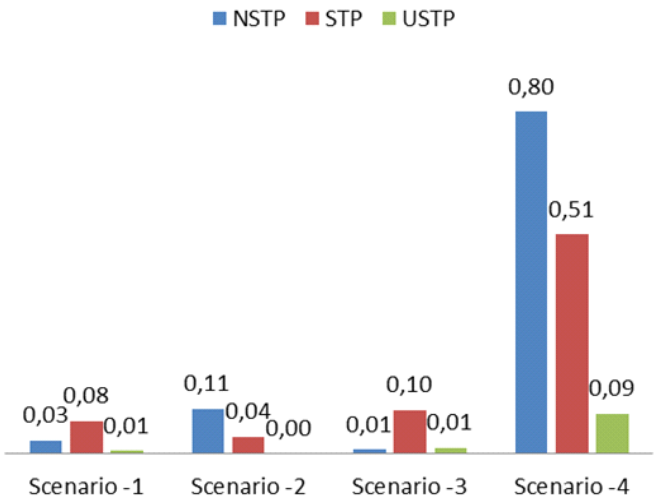

Fig. 6: Change rates in terms of time spent by patients

In Scenario-1, NSTP number increased 20%, STP number 27%, USTP 13%, and total 21%. In Scenario-2 NSTP number increased 21%, STP number 21%, USTP number 5%, and total number of the patients increased 16%. In Scenario-3 the numbers of NSTP, STP, USTP, and total increased 22, 24, 14, and 21%, respectively. In Scenario-4, the numbers of NSTP, STP, USTP, and total increased 24, 23, 2, and 17%, respectively (Fig. 5).

In terms of time spent in system: When the patients' total spent time is examined in terms of time according to Scenario-1, NSTP spend 92, STP spend 180 and USTP spend 137 hours respectively during the diagnose, test and treatment period (Table 6).

According to Scenario-1, time spent by patients in the system decreases by 3% in NSTP class, 8% in STP class and 1% in USTP class. In Scenario-2, time spent by patients in the system remained the same in NSTP and USTP classes, and increased 4% in STP class. From the results acquired in Scenario-3, it is found similar to the Scenario-2. In Scenario-4, it was determined that those durations decreased 80% in NSTP class, 51% in STP class and 9% in USTP class (Fig. 6).

Table 6: Scenario results in terms of patients' time spent in system (Hrs)

Patient groups	Scenario -1	Scenario -2	Scenario -3	Scenario -4
NSTP	92	85	94	19
STP	180	187	175	95
USTP	137	138	136	125

CONCLUSION

This study's objective is to determine the factors that increase waiting times of patients waiting for diagnosis,

test and treatment and to decrease the waiting times. The managerial system of general surgery clinic of training and research hospital was taken in hand. In early stage of this study, clinic's working processes were defined and the time interval of patients spent in system was researched from the entrance to the hospital.

In analysis stage, it is identified that three groups of patients decrease the efficient use of beds while it is predicted only to be used primarily for surgical purposes. These three patient groups consist of patients like in the following: Patients not to be operated after examination, waiting to be operated because of the pending assessments and post operation patients prolonged because of some issues. With the help of re-planning the processes, it is considered to eliminate the negative impacts of bed usage efficiency. The bottlenecks caused the patients to wait were identified and some solutions are proposed.

In this study, different scenarios were created in order to find solution-focused options and potential solution proposals for variables affecting each other. In order to eliminate the bottlenecks, working processes were re-planned and the simulation model was demonstrated. The designed model proposes doing the diagnosis before being an inpatient. With the model proposed, there had been an increase in the numbers of discharged patients.

After the study, it is showed that improving the working process will help the clinic to improve productivity and the clinic would be able to serve more patients. In this way, the time spent in system by patients would decrease; patient turnover and number of patients to be served would increase.

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REFERENCES

Anderson D.R., J.D. Sweeney and A.W. Thomas, 2000. An Introduction to Management Science Quantitative Approaches to Decision Making. South-Western College Publishing, pp: 588-589.

Baesler, F.F. and J.A. Sepulveda, 2001. Multi-objective simulation optimization for a cancer treatment center. Proceedings of the Winter Simulation Conference, pp: 1405-1411.

Barlas, Y., 2007. Ekşi Sözlük. Retrieved From: http://www.eksisozluk.com/show.asp?t=sim%C3%BClasyon, (Accessed on: February 18, 2011).

Barlas, Y. and V.G. Diker, 2000. A dynamic simulation game (Unigame) for Strategic University Management. Simulat. Gaming, 31: 331-358.

Barnes, C.D., C. Benson, J.L. Quiason and D. McGuiness, 1997. Success stories in simulation in health care. Proceedings of the Winter Simulation Conference, pp: 1280-1285.

Belek, I., 2001. Collapse of the Welfare State and the Political Economy of Health. Sorun Yayınları, Istanbul.

Çetinsaya, V., Ö. Öndemir and H. Baraçlı, 2004. Visual simulation technique using business process improvement and system implementation of a hospital. Operations Research / Industrial Engineering, 24th National Congress, Gaziantep-Adana (in Turkish).

Checkland, P., 1998. System Thinking, System Practice. John Wiley & Sons, New York, pp: 71-77.

Cipriano, L., B. Chesworth, C. Anderson and G. Zaric, 2007. Predicting Joint replacement waiting times. Healt Care Manage. Sci., 10(4): 195-215.

Duguay C., and F. Chetouane, 2007. Modeling and improving emergency department systems using discrete event. Simulation-T. Soc. Mod. Sim., 83(4): 311-320.

Esatoglu, A.E. and S. Bozat, 2002. Survey on the length of stay for the patients with chronic obstructive pulmonary disease: An application on ataturk chest disease hospital. J. Ankara Med. School, 24(4): 165-176.

Fetter, R.B. and J.D. Thompson, 1965. The simulation of hospital systems. J. Oper. Res., 13: 689-711.

Frieberg, L., 1981. Hospital utilization: Estimation and simulation tolls for the development of systematic plans and marketing strategies. J. Health Care Mark., 1(4): 32-48.

Harrel, C., B.K. Ghosh and R. Bowder, 2000. Simulation Using Promodel. McGraw Hill, Boston, pp: 3-77.

Kumari, A. and S.J. Shim, 2005. Optimal utilization of human resources in surgical instruments distribution in hospitals. 18th International Conference on Production Research, Italia.

Pulat P.S., S. Kasap and G.L. Splinter, 2001. Simulation study of an ideal primary care delivery system. Simulation-T. Soc. Mod. Sim., 76(2): 78-86.

Smith, W.G. and M.B. Solomon, 1966. A simulation of hospital admission policy. Commun. ACM, 9(5): 362-365.

Su, Q. and X. Yao, 2006. Simulation and optimization of the hospital registration process using medmodel service operations and logistics and informatics. IEEE International Conference, pp: 102-106.

Sur, H., 2009. The waste in hospitals Source: How to Slip in Front? Hospital Management Articles (in Turkish). Retrieved from: www.merih.net/ml/0mangmt.htm - 25k, (Accessed on: February 25, 2009).

Taaffe, K., M. Johnson and D. Steinmann, 2006. Improving hospital evacuation planning using simulation. Proceedings of the Winter Simulation Conference, pp: 509-515.

Uyeno, D.H., 1974. Health manpower systems: An application of simulation to the design of primary health care teams. Manage. Sci., 20(6): 981-989.

Vanberkel, P.T. and J.T. Blake, 2007. A comprehensive simulation for wait time reduction and capacity planning applied in general surgery. Health Care Manage. Sci., 10(4): 373-85.

White, K.P., 2005. A survey of data resources for simulating patient flows in healthcare delivery systems. Proceedings of the Winter Simulation Conference, pp: 926-935.

Yigit. V. and I. Agırbas, 2004. Effect of capacity utilization rate costs of hospital organizations: Ministry of health, maternity and child care hospital, tokat, an application. Hacettepe J. Health Admin., 7(2): 141-162 (in Turkish).