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OUTPATIENT HEALTH CARE FACILITY PLANNING AND SIZING VIA COMPUTER SIMULATION

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ABSTRACT

New prospective reimbursement schemes are causing adverse impact on hospitals' inpatient revenues. To blunt the impact, the hospitals have begun expanding their outpatient services through clinics, urgicenters and surgicenters. The strategy helps expand their service areas and provide significantly higher potential for revenue growth. Pricing and quality of services offered are going to be two critical success factors. This paper describes a simulation model that was used to size and plan a new outpatient surgical facility by optimizing patient wait time (quality) and facility size (price) to meet a projected demand for service.

INTRODUCTION

Outpatient Short Stay Surgery is becoming a major growth market in the health care industry. It is being heavily promoted and encouraged by regulators, third party payors and providers in an attempt to provide surgical services at low cost and avoid hospitalization costs. The historical data of surgical procedures performed on an outpatient basis conclusively show that the demand for this type of service will show a significant growth in the future. Also, as we move away from cost-based reimbursement, the emphasis on alternatives to inpatient care, and the planning and development of facilities for new ambulatory and other non-inpatient care will take on added importance in the future.

Considering the external environmental factors including the emergence of surgicenters and the substitution of many inpatient surgical procedures by procedures performed on an outpatient basis, hospital managements are feeling the pressure to expand their outpatient surgical services. One such hospital requested a study to determine the facilities required to support the increased volumes of short stay surgery patients. In particular, the questions raised related to how much additional space and how many additional carts would be needed to ensure a reasonably low patient wait time and high quality patient care in the short stay surgery unit. The existing program had already proven to be inadequate, and had resulted in significant patient wait time. Furthermore, to support the additional load, an option of extending the operating hours of the short stay surgery unit also had to be considered.

Since the exact quantification of facilities needed for such a non-existing system to be built to process the specified patient load is difficult with conventional analytical techniques, a computer simulation technique was used to evaluate various physical configurations, and quantify their impact on patient wait time, percent utilization of facilities, and overall functioning of the unit. This paper describes the architecture of such a simulation model built to analyze the short stay surgery operations under various operating conditions. It also summarizes the results and illustrates how the model can be used for facility planning.

Two critical capital resources needed for providing the short stay surgery service were identified as variables for analysis. They were: building space or slots for pre-op and post-op patients, and number of mobile carts needed for transporting patients to and from the operating room. Staff resource is also a critical resource but, since staffing levels can be easily changed from time to time depending on the need, it was not included in the simulation model.

Because of the cost-plus type of reimbursement systems that have been the main-stay in the past, the technique of computer simulation has not been effectively used for facility planning or capital expenditure decisions. Over staffing and inappropriate expansion of facilities based on intuitive judgements were the norms, and were supported by the third party payors without any penalty. However, the new prospective payment schemes will mandate a thorough cost-benefit analysis of major facility expansion plans. Thus, simulation models and decision support systems for such analysis will become necessary and essential tools for rational and good decision making. This paper describes one such tool used by a hospital in facility planning.

CURRENT SYSTEM

The hospital's current capacity to process short stay surgery patients is as follows:

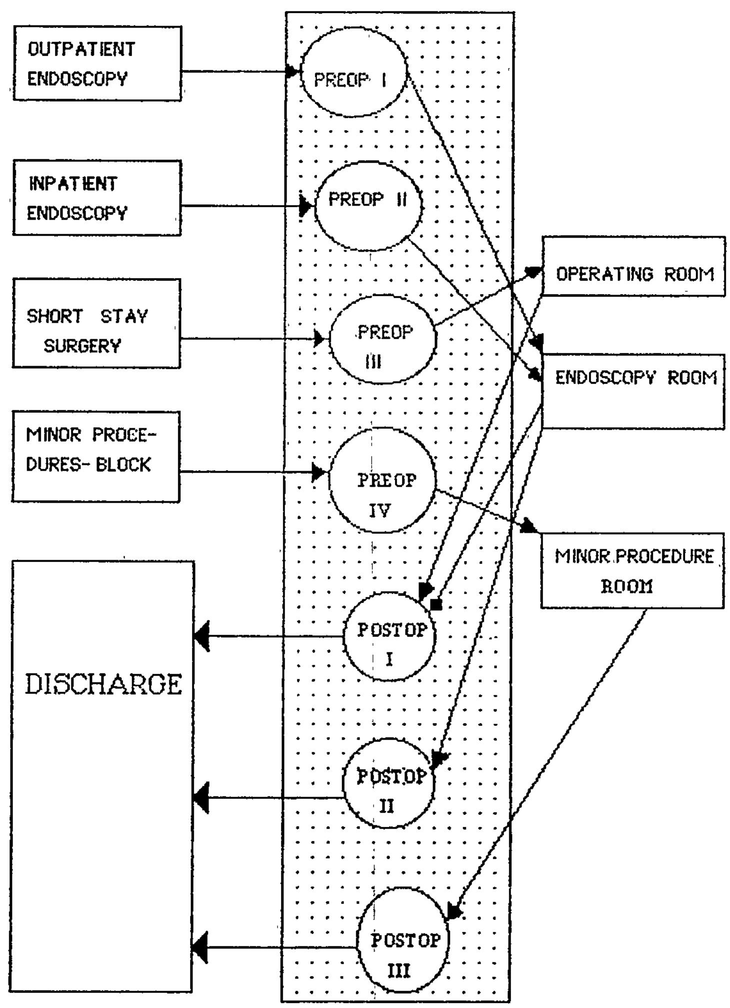
Short Stay Surgery Patients:	14 patients/day
Block Patients:	2 patients/day
Endoscopy Patients	
- Inpatients:	3 patients/day
- Outpatients:	3 patients/day
TOTAL:	22 patients/day

The facilities currently available to handle the above patient load are 13 spaces or slots in pre-op and post-op treatment room and 13 movable carts. The hospital management is considering proposals to increase the short stay surgery processing capacity from 14 patients to 24 patients and eventually to 34 patients/day. The decisions that need to be analyzed are regarding additional capital resources needed to support this expansion.

Exhibit 1 shows the schematic of the current patient flow through the short stay surgery facility. Typically, patients arrive on the day of the surgery, are assigned a cart and a slot in the pre-op/post-op

EXHIBIT 1

PATIENT FLOW DIAGRAM



room to undergo pre-op treatment and then are wheeled into the Operating Room or Endoscopy Room or Minor Procedures Room, depending upon the patient's diagnosis. Once the surgical procedure is completed, the patient is returned to the pre-op/post-op room for post-op treatment. On completion of the recovery, the patient is discharged on the same day. The cart stays with the patient from the time he arrives until he is discharged.

When the pre-op/post-op room is fully occupied, patients arriving for surgery often wait in the hallway causing inconvenience to other patients and the nursing staff. Due to lack of carts and space for pre-op and post-op patients, the nursing staff at times is also forced to provide treatment to patients under clinically undesirable conditions. For example, when a patient arrives for short stay surgery and has no available cart, he is assigned a chair and given the pre-op treatment. Or if no space is available for patients arriving from the operating room, the staff is forced to use the hallway for post-op treatment. Thus, the two critical resources required to expand the capacity, are carts and pre-op/post-op spaces. Currently, during the peak times, the patient wait time has been as high as 20 minutes, even with the inappropriate use of chairs for treating pre-op patients. However, if the system is to operate in an ideal manner, where the use of chairs or use of hallway for pre-op and post-op treatment is totally prohibited, the wait time in the current system could be as high as 40 to 60 minutes on an average, with the maximum wait time amounting close to 120 minutes. Average wait time of 10 to 15 minutes is considered essential for marketing such services in the future.

OBJECTIVES OF SIMULATION

The hospital management identified three critical questions that needed to be analyzed in this study to make a rational and good decision on expansion of the facility. They are:

1. How many carts will be required to maintain an average patient wait time of 10 to 15 minutes, with not more than 20% of all patients waiting?

2. How many spaces or slots will be required for pre-op and post-op patients, if pre-op and post-op patients are not to wait for spaces?

3. If the capital expenditure for additional space becomes a major constraint, or if it is found infeasible to add additional space or equipment, what is the maximum patient load the current system can handle, without causing major bottlenecks in the system?

In order to obtain quantitative answers to the above questions of stochastic nature, a computer simulation model is essential. The model allows the decision maker to alter the key parameters and answer "what if" questions. The key parameters that are altered in each scenario are:

- Patient arrival rates and patterns, for a specified load per day in Short Stay Surgery, Endoscopy, and Minor Procedures.
- Number of spaces available for pre-op and post-op treatment.
- Number of mobile carts available for transporting patients to and from the operating room.
- Time period during which patients are allowed to enter the short stay surgery system. For example, the model could specify that the last patient in cannot arrive later than 12 p.m. or 2 p.m., etc. or earlier than 6:30 a.m.

Given a set of above variables, the simulator is designed to provide the following key statistics:

- Average patient wait time for space <u>and</u> for carts.
- Average patient wait time of only those who waited for space and for carts.
- Percent utilization of available spaces and carts.
- Percent of arriving patients who waited.

If the hospital management, on the basis of their quality assurance goals or other corporate goals, can set a maximum wait for patients that is considered desirable from marketing point of view, the simulation results will answer the three questions raised in the study.

INPUT DATA AND ANALYSIS

The actual data was collected to determine the following:

- Patient arrival rates and patterns during the day - Inter Arrival Times.
- (Service) Time spent by each patient in each of the treatment rooms, - pre-op, surgical unit, post-op, etc. - statistical means and standards deviations of service times.
- Patient discharge rates and patterns during the day.

Means and standards deviations were calculated for each service block. The standard deviations were adjusted to ensure that the service time of a patient in any service department is always a positive number and does not fall below the minimum. Obviously, an assumption is made here that all service time distributions are normal distributions. The statistical analysis of data validated the assumption. The statistical means and standard deviations were used as input to the simulation model.

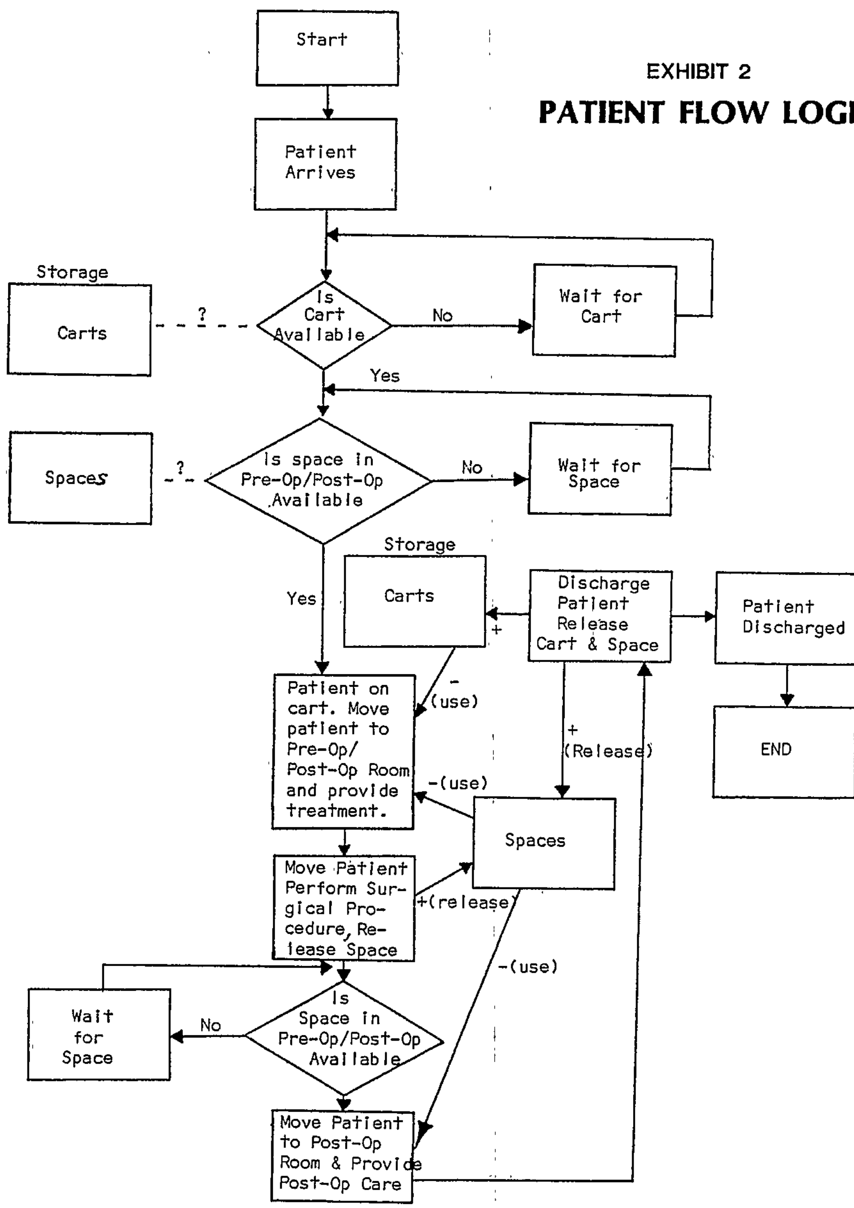
SIMULATION MODEL

The simulation model is programmed in GPSS-H with interactive debugging feature. The model runs on the University of Michigan Terminal System (MTS). Exhibit 2 shows the simulation logic used to process the patients in the short stay surgery unit. The unit consists of the following rooms:

- Pre-op/Post-op Room is divided into the following rooms to ensure homogeneity in time characteristics of patients processed. (See Exhibit 1.)
  - Pre-op Room I for Outpatient Endo patients: Mean Service Time = 42 minutes and standard deviation = 8 minutes.

EXHIBIT 2

PATIENT FLOW LOGIC



- Pre-op Room II for Inpatient Endo Patients: Mean Service Time = 40 minutes and Standard Deviation = 8 minutes.
- Pre-op Room III for Short Stay Surgery patients going to the Operating Room: Mean Service Time = 100 minutes and Standard Deviation = 20 minutes.
- Pre-op IV for Outpatient Block Patients: Mean Service Time = 23 minutes and Standard Deviation = 4 minutes.
- Post-op I for 50% of Outpatient Endo Patients and all Inpatient Endo and all Short Stay Surgery patients: Mean Service Time = 140 minutes and Standard Deviation = 30 minutes.
- Post-op II for 50% of Outpatient Endo patients: Mean Service Time = 55 minutes and Standard Deviation = 10 minutes.
- Post-op III for Block patients coming from Minor Procedures Room: Mean Service Time = 50 minutes and Standard Deviation = 10 minutes.

- Short Stay Surgery/Operating Room Procedures
  Mean Service Time = 150 minutes
  Standard Deviation = 30 minutes
- Endoscopy Room Procedures
  Mean Service Time = 48 minutes
  Standard Deviation = 9 minutes
- Minor Procedures Room (Block Patients)
  Mean Service Time = 83 minutes
  Standard Deviation = 16 minutes

It was also assumed that on an average, it takes 3 minutes for patients to move from one room to another. Patients arrive according to a parameter (mean inter-arrival time) driven Poisson Distribution, input to the model.

50% of the Outpatient Endoscopy patients go to Post-op Room I for post-op treatment and the remaining 50% go to Post-op Room II as shown in Exhibit 1.

The model processes the patients as specified in the patient flow diagram (Exhibits 1 and 2) and collects statistical data on simulated patient wait times and utilization of facilities (carts and spaces).

PLANNING SCENARIOS

The Hospital management proposed 4 scenarios for evaluation. In each scenario, the patient load and arriving patterns of both Inpatient and Outpatient Endo and Block patients were kept the same. The only variable that changed in each scenario was the arrival pattern and number of short stay surgery patients: The following 4 scenarios were evaluated. In each scenario, patients arrive no earlier than 6:00 a.m.

- Scenario I: Simulate the current system wherein an average of 14 short stay surgery patients arrive during the day with the last patient arriving not later than 11:45 a.m. This was used to validate the model.
- Scenario II: Short Stay Surgery patient load is increased from 14 patients to 24 patients and the last patient arrives not later than 2:00 p.m.
- Scenario III: Same as Scenario II except the last patient arrives not later than 11:45 a.m.
- Scenario IV: Short Stay Surgery load is increased to 34 patients per day and the last patient arrives not later than 2:00 p.m.

RESULTS

Exhibit 3 shows the summary results of the various simulation experiments. Current and ideal modes of operation shown in Exhibit 3 (shaded blocks) were defined as follows:

- Current Mode of Operation: Use of chairs and hallway for pre-op and post-op is permitted wherein the average patient wait time for carts amounts to approximately 35-40 minutes. This is the wait time under the current scenario with 13 carts and 13 spaces.
- Ideal Mode of Operation: Use of chairs and hallways for pre-op and post-op is totally prohibited. A pre-op space and a cart must be available prior to beginning the pre-op treatment. An average wait time of 10-15 minutes for carts was considered reasonable and acceptable to define this mode.

Obviously, if the current mode of operation wherein chairs and hallways are used for pre-op and post-op treatment is continued, the facilities required (number of carts and number of spaces) will be less than if the use of cart and pre-op/post-op space is made mandatory for treating patients. The facilities required were thus determined under the current mode of operation and also under an ideal mode of Operation (wherein use of chairs and hallways for patient treatment are not permitted).

Based on the above definitions, the facility setups for the current and the ideal modes of operation for each scenario were arrived at. They are highlighted in Exhibit 3.

Exhibit 4 shows the summary results derived from Exhibit 3. The first two rows of Exhibit 4 show the number of carts required. The third row shows the impact of not adding any additional pre-op/post-op spaces to the 13 existing spaces. Here all patients who arrive and do not have any space available in pre-op and post-op room, are forced to exit the system, thus giving the maximum number of patients the system can handle without any space bottlenecks. Row four indicates the maximum number of spaces required to accommodate the peak load of patients in pre-op/post-op room. This implies no wait time for space for pre-op or post-op patients. The simulation model can be easily used to simulate any other scenario not addressed in this report.

It is obvious from the results that carts were a more critical resource than space in all future scenarios.

EXHIBIT 3

SSS FACILITY PLANNING SCENARIOS

Wait Statistics

No. of Spaces	No. of Carts	SCENARIO I 14 SSS/Day 11:45 a.m.								SCENARIO II 24 SSS/Day 2:00 p.m.							
		Avg. Wait Time - All		Avg. Wait Time-Waited		% Zero Wait		Max. # Waiting		Avg. Wait Time - All		Avg. Wait Time-Waited		% Zero Wait		Max. # Waiting	
S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C
13	13	0.0	43	[illegible]	[illegible]	100	66	[illegible]	12								
13	15	0.15	23	8	98	99	77	1	10								
13	17	0.2	11	[illegible]	[illegible]	[illegible]	86	[illegible]	[illegible]	1.5	59	15	136	90	57	4	20
13	19	0.4	4	12	57	96	92	4	7	[illegible]	[illegible]	20	110	84	65	6	19
13	21	0.8	1	16	44	95	97	6	5	4.8	24	24	87	80	72	8	15
13	23	0.9	.2	16	32	94	99	7	3	5.9	[illegible]	24	68	75	80	9	14
13	25	0.96	0	16.7	18	94	100	7	1	7.8	7.7	28.5	62.4	73	88	11	12
13	27									8.9	3.8	30.7	33.4	71	93	11	10
13	29									9.8	2.2	32.6	53.3	70	96	13	10
13	31									10.1	0.9	34	45.0	70	98	13	9

No. of Spaces	No. of Carts	SCENARIO III 24 SSS/Day 11:45 p.m.								SCENARIO IV 34 SSS/Day 2:00 p.m.							
		Avg. Wait Time - All		Avg. Wait Time-Waited		% Zero Wait		Max. # Waiting		Avg. Wait Time - All		Avg. Wait Time-Waited		% Zero Wait		Max. # Waiting	
S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C
13	13																
13	15																
13	17	2.1	77.4	15.9	175	86	56	4	22	2.0	128	15.6	221.5	87	42	4	31
13	19	4.2	55.8	21.9	152	81	63	6	21	4.6	94	20.2	180.0	77	48	6	27
13	21	[illegible]	[illegible]	[illegible]	[illegible]	76	70	8	[illegible]	7.6	69.7	25.6	150.0	70	53.4	8	28
13	23	7.3	25.8	28.6	112	74	77	10	16	12.0	51.3	32.6	128.0	63	60	10	25
13	25	[illegible]	[illegible]	[illegible]	[illegible]	71	83	12	14	[illegible]	[illegible]	36.4	[illegible]	80	66	[illegible]	23
13	27	9.7	9;8	29.9	89.5	67	89	14	12	19.5	27.0	42.5	98.0	54	72	14	22
13	29	11.5	5.6	32.7	81.6	65	93	14	11	23.1	19.2	47.6	89.6	51	79.	16	20
13	31	12.3	3.1	33.5	75.8	63	96	15	9	[illegible]	[illegible]	51.7	[illegible]	50	85	18	15

Current Mode of Operation

Ideal Mode of Operation

CONCLUSIONS/SUMMARY

- Use of chairs and hallways for pre-op and post-op treatment short stay surgery patients should be discouraged due to clinical and quality assurance considerations. The ideal mode of operation, as defined in this report, should be made an operational goal.
- The reasonable maximum short stay surgery patient volume the present facility can handle without major bottlenecks is 24 patients per day.
- To accommodate a demand of 24 short stay surgery patients (Scenario 2) in addition to eight Endo and Minor Procedure patients, additional carts and spaces are needed: A total of 23 carts and 5 additional spaces in pre-op and post-op treatment. Since the patients returning from surgery must have a space for recovery, it is clear that the use of the current 13 spaces will result in greater than 10 minute wait time.
- Since the patients waiting for pre-op space need a waiting room and the maximum queue length during the day was as much as 12 patients, a waiting room to accommodate 10 - 12 patients would also be desirable.
- Simulation technique is an effective and inexpensive tool that can be used by the health care industry on a more extensive basis so that the future facilities are sized to meet the demand and are utilized to their fullest extent.

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EXHIBIT 4

SUMMARY OF SIMULATION RESULTS

	Scenario I Current 14/Day 11:45 a.m.	Scenario II 24/Day 2:00 p.m.	Scenario III 24/day 11:45 a.m.	Scenario IV 34/day 2:00 p.m.
Current Mode: Carts Required	13	19	21	25
Ideal Mode: Carts Required	17	23	25	29
Maximum Patient Load Permissible Without adding spaces	13.6/ Day	21.2/ Day	21.0/ Day	24.4/ Day
Maximum Spaces Required	16	22	24	28