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EVALUATING SURGICAL BLOCK SCHEDULES USING COMPUTER SIMULATION

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ABSTRACT

This paper describes the use of a computer simulation model in evaluating the scheduling of surgical patients in an operating room. The concepts of block scheduling are discussed. An actual application of the model is described. Example inputs, outputs, and uses of the model are presented.

INTRODUCTION

The need to control hospital costs and improve resource utilization has become increasingly important. This is particularly true of the operating room (O.R.) suite, where the large capital and labor costs associated with the facility have significant financial impacts. Good O.R. scheduling procedures are crucial to achieving an efficiently utilized facility. This paper discusses the use of a simulation model to investigate different O.R. scheduling strategies.

BLOCK SCHEDULING

Block scheduling is a frequently used method for scheduling cases in an O.R.. A block scheduling system is where a block of operating room time is reserved for an individual surgeon or a designated group of surgeons. The given surgeon may hold several different blocks of time over a week. These blocks remain constant from week to week. Blocks allow the surgeon to more reliably predict when he will be in the O.R., which permits a more organized schedule for his office practice. At the same time, this system aids the O.R. manager in booking certain times of the day that would otherwise be considered undesirable, thereby increasing utilization of the facility. For these reasons, many authors believe a block system can be both efficient for the O.R. and of service to the physician (8, 12).

To increase the flexibility of a block schedule, the blocks mays be released 1, 2, or 3 days in advance and opened to other surgeons on a first come first serve basis. This strategy allows subspecialists who cannot schedule cases far in advance to have increased access to the facility.

Great care must be taken to construct a good block schedule. First and foremost, the total blocked time for a given surgeon must match the estimated time needed to complete the number of operations he is expected to perform over the time interval of interest. If blocked time is set too large, under-utilization of the facility results. If it is set too small, one of two situations will result. Either the delay in getting on the schedule will increase or the physician will request a case be performed after hours and overtime will result. Therefore, the major tradeoff in block scheduling is the balancing of overtime and booking delays against facility utilization.

Scheduling in the O.R. is further complicated by the random nature of case load and case time. These random variables need to be considered in evaluating a block schedule.

MODEL DEVELOPMENT

The O.R. scheduling model built used the SLAM II® simulation language [10]. The model utilizes the discrete/network portions of SLAM II and is composed of four major components. These components are:

1. Block Schedule Input. Prior to execution of the simulation, data associated with the block schedule is input to the model. This data includes start and end times for particular groups of blocks, the identification of the surgeons assigned these blocks, and group scheduling preference information.

   Schedule data is input on a day of week basis by surgical groups using the same block start and end times. This structure allows the user to sccount for any anomalies in the schedule. This would occur, e.g., if on Wednesday morning only two of the facility's five available O.R.'s are scheduled to be open.

   All relevant schedule data is echoed back to the user to verify the specifics being evaluated by the model. An example of such an echo is shown in Figure 1. This

BLOCK SCHEDULE USED TO ASSIGN PROCEDURES

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
PERIOD NO. ; 1 PERIOD START TIME ; 800 HRS. PERIOD END TIME ; 1200 HRS. PERIOD LENGTH ; 240 MINS.	ORTHO-1 GENERAL-1 ORTHO-2 UROLOGY NEURO	ORTHO-1 GENERAL-1 UROLOGY OB/GYN ORTHO-2	ORTHO-1 GENERAL-1 GENERAL OB/GYN	ORTHO-1 GENERAL-1 OB/GYN ENT ORTHO-2	ORTHO-1 GENERAL-1 ORTHO-2 ENT OTHER
PERIOD NO. ; 2 PERIOD START TIME ; 1200 HRS. PERIOD END TIME ; 1330 HRS. PERIOD LENGTH ; 90 MINS.	ORTHO-1	GEN/PRAC	GEN/PRAC	ORTHO-1	GEN/PRAC
PERIOD NO. ; 3 PERIOD START TIME ; 1230 HRS. PERIOD END TIME ; 1530 HRS. PERIOD LENGTH ; 180 MINS.	GENERAL-1 OB/GYN GENERAL-2 ORTHO-2	GENERAL-1 GENERAL-1 OB/GYN ENT	GENERAL-1 UROLOGY NEURO ENT	GENERAL-1 ORTHO-2 ORAL-PODIATRY PLASTIC	GENERAL-1 OB/GYN UROLOGY ORTHO-2
PERIOD NO. ; 4 PERIOD START TIME ; 1330 HRS. PERIOD END TIME ; 1700 HRS. PERIOD LENGTH ; 210 MINS.	ORTHO-1	ORTHO-1	ORTHO-1	ORTHO-1	ORTHO-1

Figure 1, Echo of Block Schedule Produced by Model.

schedule shows four different periods of time, called block periods, when rooms are operational. During block period 1 (8:00 a.m. to 12:00 noon) five rooms are scheduled on Monday, Tuesday, Thursday, and Friday. On Wednesday, only four rooms are scheduled during this time. Looking at block period 4, it can be seen that one room is allocated time between 1:30 and 5:00 p.m. This is a continuation of service by the room scheduled in block period 2 between noon and 1:30 p.m. The remaining four rooms in this schedule run between noon and 3:30 p.m. as scheduled in block period 3.

2. Room Request Generation. This component of the model issues the requests to the O.R. scheduler for time to perform a surgical procedure. In the model, requests for regular and day surgeries are generated on a daily basis by drawing a sample from a Poisson distribution. The mean of this distribution was determined from the hospital's surgical records. Once generated, the room requests are scheduled to reach the scheduler randomly throughout the O.R. work day (e.g., 8:00 a.m. to 5:00 p.m.).

Emergent patterns are handled in a slightly different manner. These arrivals are generated by the model using an exponential interarrival distribution based on the hospital's historical data. Since emergent patients arriving after regular scheduled O.R. hours have no impact on the surgery schedule, they are 'thrown away' by the model. Those ER patients arriving during regular hours are given to the O.R. along with the scheduled patients.

Once a request is generated, the characteristics of that request are determined. These include type (regular, day, or emergent) provider groups (e.g., orthopedic or OB/GYN), and estimated procedure time. In the model, these patient characteristic assignments are accomplished using a SLAM II network fashioned in a tree-like structure. In this structure, patients are assigned a type. Then, based upon their type, the patient is probabilistically assigned to a surgeon or group. Finally, based on that group and their patient type, a mean procedure time is computed.

3. Patient Scheduling. Once a request is generated and its assigned characteristics are determined by the network, it is processed through a SLAM II EVENT node. At the scheduler, the request's type is matched with the groups in the schedule. When a match is found, the request's estimated procedure time is compared with the time remaining in the block. If sufficient time is available (including room turnover), the case is booked on the schedule. If time is not available at the point in the schedule, the search process continues.

   Besides the group ID search and checking for available comparisons, the scheduler must also consider other factors. These include using released time on the schedule if possible, restricting certain groups to access only in their block(s), and not allowing groups to access blocks set aside for day surgeries.

4. Patient Servicing. Once scheduled to arrive, a scheduled surgery is returned to the network portion of the model. Upon arrival, this surgery is placed in a queue to await an available O.R. Emergent patients are immediately sent to this queue upon generation. When an O.R. becomes available, these patients are assigned the room based upon their patient type and their scheduled start of surgery.

   For some evaluations made using the model, special facilities reserved for day surgeries are evaluated. This involves the patient arriving early and awaiting a bed, undergoing pre-operation procedures, then awaiting for the special day surgery O.R. Once the procedure is completed, these patients return to their recovery bed for a time, then leave the facility.

   To compute the actual time taken by a given procedure, a sample is drawn from a lognormal distribution using the mean procedure time assigned the patient earlier. The selection of a lognormal distribution was made after analysis of the hospital's surgical records. Note that since scheduling was based on expected time, there exists the possibility for extreme variation between scheduled and actual performance of the facility. These variabilities impact both the early/late start of surgical patients as well as the O.R.'s overtime.

An overview of the model is shown in Figure 2. This figure indicates how the different components interrelate with respect to request generation, characteristic assignment, and patient servicing. The numbers in the figure refer to the case load of the facility whose scheduling policies were being evaluated.

OUTPUTS FROM THE MODEL

Outputs from the model included the following:

1. Access delays (i.e., how long a surgeon must wait until a requested surgery gets on the schedule);

2. Room utilization statistics;

3. Schedule delays, i.e., the difference between scheduled start of procedure and actual start; and

4. Number of rooms in use at scheduled room shutdown times and at half hour intervals thereafter (i.e., overtime cases).

The outputs from the model were based on runs of 30 and 60 days, collected after statistics were cleared for a ten day period. This period was selected to allow the facility and the schedule book to reach steady state.

APPLICATION OF THE MODEL

The model developed was used to evaluate the O.R. scheduling policies for a 150 bed community hospital (in the Pacific Northwest). This hospital was experiencing high utilization of its O.R. facilities but at the expense of substantial overtime and access delays for some practitioners.

The block scheduling used for this hospital's O.R. suite allocated time for twelve groups of practitioners. These groups corresponded to surgical subspecialties (i.e., OB/GYN, ENT) with some added distinctions for large volume surgeons (i.e., two separate groups of orthopedic surgeons were assigned separate blocks). These groups were assigned blocks of time between 8:00 a.m. and 5:00 p.m. from Monday to Friday. Unused time was released for access by any surgeon 48 hours in advance. The facility operated initially with five O.R.'s. The hospital serviced 12,000 admissions and approximately 5,500 surgeries per year.

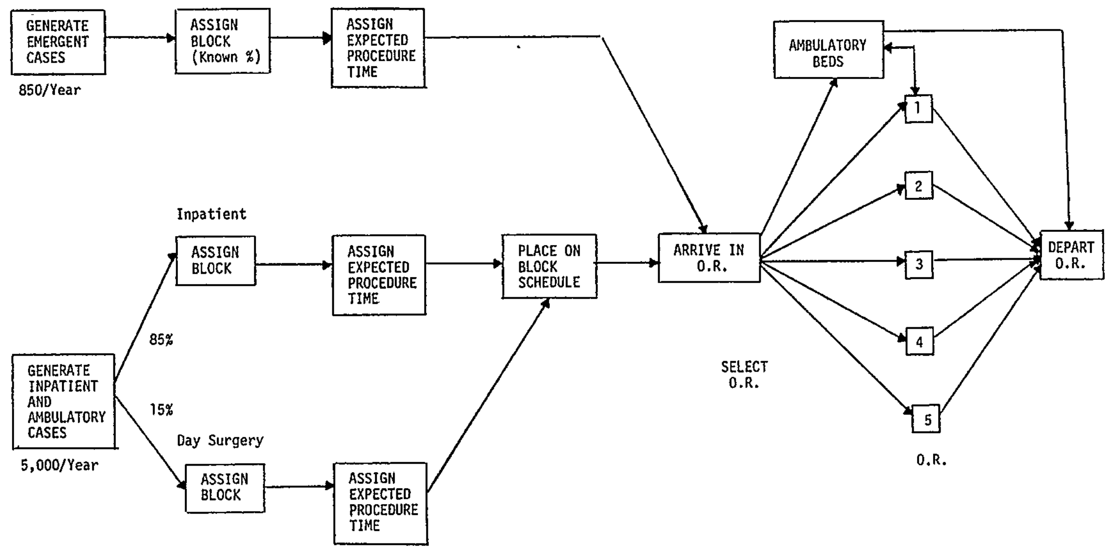

Figure 2. Overview of O.R. Scheduling Model.

The model was initially validated against the schedule and case mix situation for 1984. Data for the model was obtained from a computerized database developed from the O.R. log. This data permitted the estimation of the number of case requests per day by specialty. In addition, procedure times by specialty were characterized from this database into statistical distributions. The model was validated using data from the previous year. The model was then used to evaluate several proposed block schedules.

RESULTS

As mentioned, the model was first validated against a 1984 schedule and case mix. The results from this run agreed closely with the utilization (approximately 83%) and delay situation experienced by the hospital. In particular, the model pinpointed one practice group whose access delays to the schedule were becoming intolerable due to the group's preference to utilize only its own block time. The model also indicated that several blocks were inefficiently sized for the groups using them.

Example model output is shown in Figure 3 and Figure 4. The first histogram represents an estimate of the number of rooms that are still be operating at the end of the shift. This represents a measure of overtime and was useful in estimating the effects of scheduling changes on staffing levels. The graph reveals that 43.3 percent of the time, one room is still operating at the scheduled closing time (3:30 p.m.) and 20 percent of the time, four or five rooms will be active at this time.

The second histogram (Figure 4) is an estimate of the delay a surgeon group may expect in getting on the OR schedule. The histogram reveals that this particular group waited up to ten days to get a case on the schedule. Alternative schedules were compared with this statistic in mind.

Based on these results, as well as extensive interviews with the hospital staff, three alternative schedules were developed and evaluated using the model. These schedules placed low volume groups into a single general block, extended block times for the major groups, and slightly increased available hours for the entire schedule. These modifications resulted in O.R. utilizations in the 73 to 75 percent range, shorter access times for the surgeons, and reductions in overtime.

OTHER USES OF THE MODEL

Changes resulting from a significant shift to outpatient surgery were also evaluated using the model. Based on case mix projections for 1990, a series of analyses was performed to examine the effects of dedicated outpatient surgical facilities and the scheduling of outpatients. These runs suggested workable room and scheduling alternatives based on a projected shift in day surgeries from 15 to 40 percent of the total procedures occurred. These

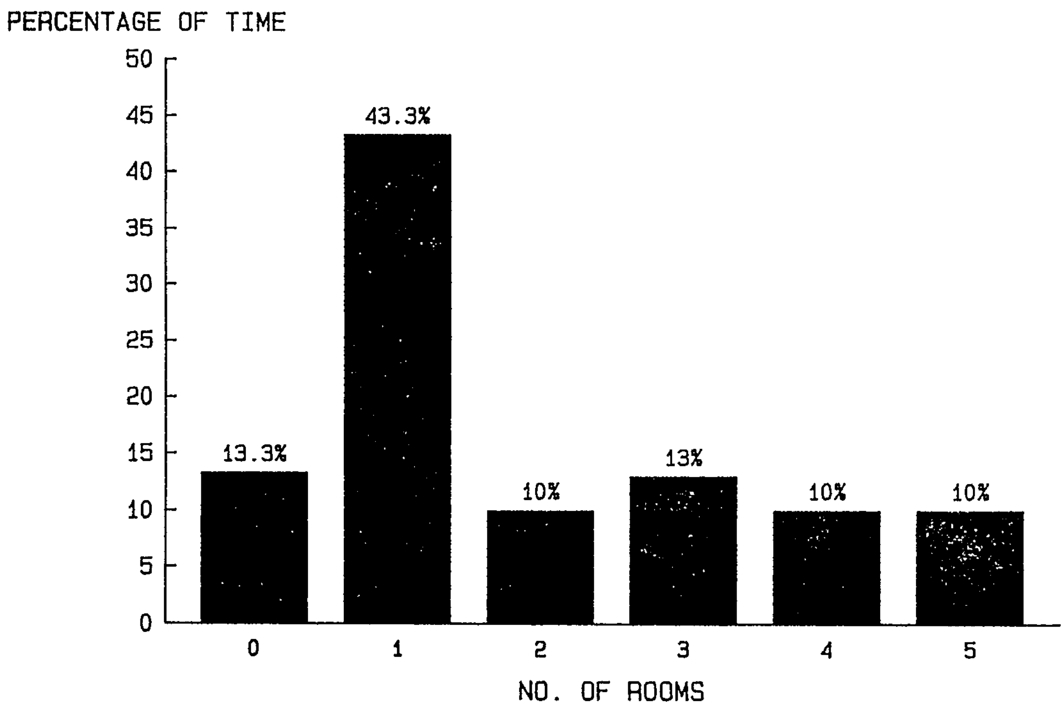

Figure 3. Model Output Representing a Measure of Overtime.

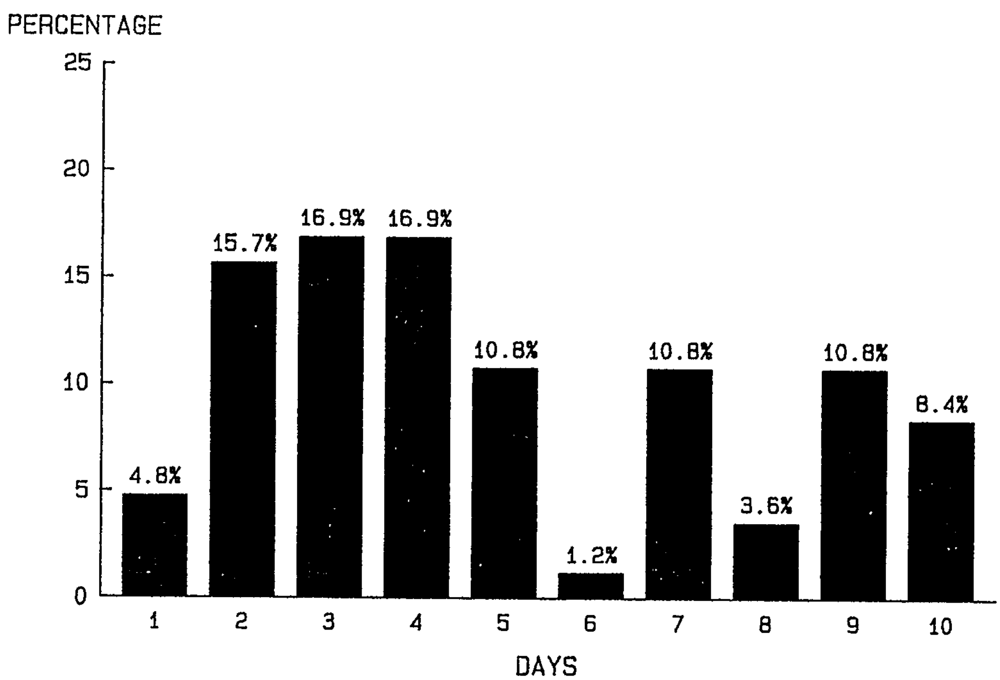

Figure 4. Model Output Estimating Delay of Orthopedic Surgeons Accessing Schedule.

runs indicated that the most efficient utilization of the facilities would result if outpatients blocks were added to the schedule on certain mornings during the week. The results also indicated that no special distinction between inpatient and outpatient O.R. rooms should be made.

SUMMARY AND CONCLUSIONS

Once a general O.R. scheduling model has been developed, it can provide insight for a number of questions facing the facility's staff and administration. It also provides a tool that has ongoing use as case mix, facilities, and scheduling policies change. Finally, the process of analyzing the data required for the model can provide insight into the operation of the facility itself.

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