A SIMULATION STUDY OF THE LABOR AND DELIVERY ROOMS AT JMH

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ABSTRACT

This paper presents a simulation model of the operations in the Labor and Delivery Rooms at Jackson Memorial Hospital. A thorough analysis of the contents of hospital's databases revealed that although there is a significant amount of data, some of it is not usable. Nonetheless, with the available data, it was possible to establish relatively good inputs for the simulation model. Furthermore, it was possible to do a correlation analysis to determine which factors affect the procedure service times in the OR and Recovery areas. The simulation model has yielded results to improve doctor scheduling and better staffing levels.

1 INTRODUCTION

Established in 1918, Jackson Memorial Hospital (JMH) is under the jurisdiction of the Public Health Trust of Dade County, Florida. The Public Health Trust was created by the Dade County Board of County Commissioners in 1973 and is the governing body of Jackson Memorial Hospital. At the core of the medical center are the University of Miami School of Medicine and Jackson Memorial Hospital. Jackson Memorial Hospital is an accredited, not-for-profit, major tertiary teaching hospital. The facility is one of the largest hospitals under a single license in the United States, with 1,567 total beds and comprehensive care in 48 areas of clinical services. Ranked by physicians as one of the nation's top 25 medical centers and the largest in the southeastern United States, the University of Miami/Jackson Memorial Medical Center occupies 67 acres in the Civic Center area of Miami and easily accessible by MetroRail or other public transit.

The Engineering Management at Jackson Memorial Hospital wants to evaluate the processes followed in the Labor and Delivery Rooms to aid in the assessment and improvement of the different processes. The Engineering Management's main objective is to implement alternative scenarios that improve the patient flow, and the rooms and staffing utilization for the Labor and Delivery Rooms (L&D).

A simulation model of the current operational procedures has been developed to investigate several possible changes to the operational procedures. These changes could be in four possible areas: 1) The scheduling of patients, 2) The staffing scheduling, 3) The Room scheduling, and 4) The Doctor's room assignment.

Section 2 describes the processes in the L&D area. Section 3 discusses the analysis if the inputs. Section 4 discusses the ARENA model. Finally, section 5 summarizes the findings and recommendations are presented.

2 THE LABOR AND DELIVERY AREA

The Engineering Management at Jackson Memorial Hospital is interested in a study of the different flows for their Labor and Delivery Rooms. This area consists of two departments: 1) the Holding and Recovery department (5 and 6 beds respectively) and 2) the Operating Room (OR) department (2 rooms for "regular procedures" and 1 room for multiple births).

It is believed that the inefficiencies to the patient flow in this department are due to poor scheduling of patients, staff, and the operating rooms. This results in patients waiting excessive time for their procedure to begin, staff working overtime, and low utilization of the operating rooms. Several visits to the Labor and Delivery Rooms were made to become familiar with the actual operational flows in the Holding and Recovery, and the Operating Rooms (OR.) Interviews were conducted during each trip with the Head Nurse and personnel to clarify some aspects of the different events that took place in both sections of the Labor and Delivery Rooms. Figure 1 is the product of several refinements. The patient arrives and is directed to the Holding area or to the OR. If the patient goes to the Holding area, he/she seizes the Holding nurse and goes through the pre-operation procedures before being sent to the OR. A patient may be cancelled at any time while in the holding area. If the patient is not cancelled, the patient continues on to the assigned OR with an OR-Nurse. The

Anesthesia Attending arrives to the OR and administers anesthesia. Next the Surgeon Attending arrives to the OR. Up to this point, once the patient is in the OR, an operation may be aborted prior to the start of incision. Incision begins once the anesthesia takes effect. Surgery and dressing are then performed. The patient is now ready to leave the OR. Depending on the patient-type, he/she is sent to the L&D Recovery area or to a Recovery area "outside the boundaries of the system" being modeled. If the patient is sent to the L&D Recovery area, the risk factor is assigned. Then, the patient is eligible for discharged some time after.

3 ESTABLISHING MODEL INPUTS

The Engineering Management Group at Jackson Memorial Hospital provided data for year 1999 for the purpose of determining statistical distributions necessary for the proposed simulation model. The data was presented in the form of a database from the OB and OBPAR departments.

The main objective of the data analysis was to establish the following inputs:

1. Number of patients by weekday per patient type.
2. Percentage of each patient type.

3. Percent of cancellations and of aborted patients.
4. Percent of OR rooms use.
5. Percent of Recovery area use.
6. Percentage of other recovery patients for each weekday.
7. Time spent in the Recovery area.
8. Risk factor.

After careful examination of the OB and OBPAR databases, it was established that there were 3,309 records in the OB database and 3,500 records in the OBPAR database. However, for some of the inputs listed before, certain records were not useful.

The following inputs were establish using the 3,309 records in the OB database for *Elective scheduled, Elective Add-on* and *Emergency* patients:

1. Number of patients by weekday per patient type.
2. Percentage of each patient type.
3. Percent of cancellations.
4. Percent of aborted patients.
5. Percent of OR rooms use.
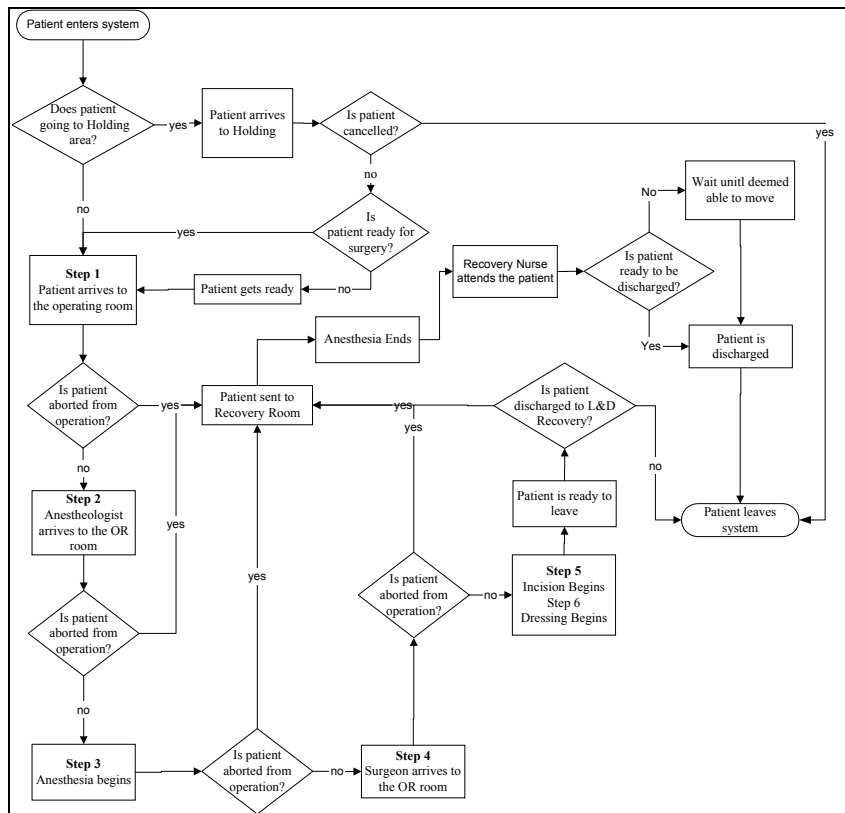6. Percent of Recovery area use.

Figure 1: Flow of Patients

The following inputs were establish for the *Other Recovery* patients that use the L&D recovery area from the 3,582 records in OBPAR database:

1. Percentage of other recovery patients for each weekday.
2. Time spent in the Recovery area.
3. Risk factor.

To extract any further information regarding a patient, the two databases had to be combined. The combination was found at the intersection of both databases where the records were of the same patient. The combination yielded 1,700 records. From the combined database, the risk factor for the *Elective scheduled and Elective Add-on* and *Emergency* patients was determined. However, it was discover that some records had a *negative* service time for some procedures; thus, these records were deemed invalids. Invalid records had to be deleted from the now combined database, ending up with 1,496 records. With these records the following inputs were determined:

1. Service time for each procedure for each patient time.
2. Recovery tome for *Elective scheduled and Elective Add-on* and *Emergency* patients.
3. Necessary data for correlation analysis.

Based on the interviews, there are two main patient types that use the OB OR: *Elective* and *Emergency*. However, a distinction may be made among elective patients. They may be *Scheduled* a head of time, or they may be *Added on* to that days schedule of patients who will visit the department. There are also Extra Recovery patients that arrive to the L&D Recovery area from an OR that is not controlled by L&D. These patients account for 10% of the patients who use the L&D Recovery area. The final patient classifications is as follows

1. *Add-on electives*. These patients were scheduled the same day of surgery.
2. *Scheduled Electives*. These patients were scheduled a couple days before the day of surgery.
3. *Emergencies*. These patients were daily emergencies.
4. *Extra-people recovery*. These were patients brought to the Recovery area from outside the study's boundaries not concerned for the simulation study.

Table 1 shows the total number of patients who were processed in the OB OR as indicated in the OB database and Table 2 shows the total number of patients that visited the L&D Recovery area as indicated in the OP PAR database for 1999: All patients were also classified as *High Risk* or *No Risk*. This distinction was determined from the combined OB and OBPAR database for the *Add-on Elective*, *Scheduled Elective*, and *Emergency* cases and the OBPAR for the *Extra-people recovery*. Based on interviews, there are five types of procedures that a patient may undergo. These are BTL, Cerclage, C-section, GYN/GYO and Other. Table 3 to 5 provide percentages of each patient type for each procedure and for each day of the week.

The Operating Rooms were assigned to patients by procedure per day of the week. Table 6 is a sample of this assignment. The frequency of use for each specific Recovery area under the control of the L&D department (HR RECOV and OBPAR) and Other Recovery areas, which are out of simulation system's boundaries, was determined and then from this the percentage of each patient type for use of this are was calculated. A sample of the use of the Recovery areas is detailed in Table 7. Some patients have no entry for "Postdispo" (assigned Recovery area) within the OB database; a blank cell within the database represents this. The distinction is implemented in the model for *Performed* and *Aborted* patients. *Cancelled* patients never enter the Operating Room and hence do not visit the Recovery Area.

Table 1: Patients to the OB OR

Case Type	Schedule	Total	%
Elective	Add-on	1179	35.6%
	Scheduled	733	22.2%
Emergency		1397	42.2%
Grand Total		3309	100.0%

Table 2: Patients that Visit L&D Recovery Area

From	Total	Percent of Total
OB OR	3217	89.8%
ET4B	19	0.5%
JNORTH	1	0.0%
LDR	202	5.6%
OTHER	135	3.8%
TRIAGE	8	0.2%
Grand Total	3582	100.0%

Table 3: Percentage of Procedure Type by Day of Week - Elective Scheduled Patients

Procedure	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Gyn/GyoO	7.1	62.7	4.0	1.3	3.4	0.0	0.0
Btl	2.0	1.3	2.4	7.8	4.5	50.0	0.0
Cerclage	10.1	6.3	7.3	6.5	5.7	0.0	0.0
C-section	66.7	17.7	46.8	59.7	61.4	50.0	100
Other	14.1	12.0	39.5	24.7	25.0	0.0	0.0
Total	100	100	100	100	100	100	100

Table 4: Percentage of Procedure Type by Day of Week - Elective Add-on Patients

Procedure	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Gyn/Gyo	4.9	11.0	8.3	10.3	4.4	1.8	0.8
Btl	37.1	48.0	46.2	48.6	44.4	50.9	53.6
Cerclage	2.8	0.0	1.8	3.2	2.8	0.6	0.8
C-section	43.4	33.5	38.5	35.7	45.6	40.2	40.0
Other	11.9	7.5	5.3	2.2	2.8	6.5	4.8
Total	100	100	100	100	100	100	100

Table 5: Percentage of Procedure Type by Day of Week - Emergency Patients

Procedure	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Gyn/Gyo	2.2	3.5	1.8	3.6	1.9	1.1	1.3
Btl	3.4	3.1	4.1	3.6	1.4	2.2	3.4
Cerclage	1.7	2.2	1.4	1.0	3.7	0.0	0.0
C-section	81.0	79.7	76.7	74.6	80.1	86.6	84.6
Other	11.7	11.5	16.0	17.3	13.0	10.2	10.7
Total	100	100	100	100	100	100	100

Table 6: O. R. Assignment per Patient Type – Monday

Elective Scheduled	Room Number		
Procedure	41	44	45
GYN/GYO	14.3%	85.7%	100.0%
BTL	0.0%	100.0%	100.0%
CERCLAGE	30.0%	60.0%	100.0%
C-SECTION	24.2%	56.1%	100.0%
OTHER	0.0%	57.1%	100.0%
Elective Add-On	**Room Number**		
Procedure	41	44	45
GYN/GYO	0.0%	71.4%	100.0%
BTL	11.3%	54.7%	100.0%
CERCLAGE	0.0%	25.0%	100.0%
C-SECTION	4.8%	40.3%	100.0%
OTHER	23.5%	88.2%	100.0%
Emergency	**Room Number**		
Procedure	41	44	45
GYN/GYO	25.0%	75.0%	100.0%
BTL	16.7%	50.0%	100.0%
CERCLAGE	0.0%	66.7%	100.0%
C-SECTION	9.7%	36.6%	100.0%
OTHER	23.8%	71.4%	100.0%

Table 7: Recovery Area Use - Elective Scheduled Patients

Postop Dispo	Aborted	Cancelled	Performed	Total
HR Recov.	0	0	0	0
OBPAR Recovery	6	1	495	502
(blank)	0	206	25	231
Total	6	207	520	733
OBPAR Recovery	100	100	100	100

The total number of patients per patient type that arrive to the simulation system per day were determine from the OB database. Table 8 shows a sample of the average number of patients per patient type for each day of the week. All Elective Scheduled patients enter the OR in batches at 6 a.m. and at 2 p.m. The time between the arrival of each patient for Elective Add-on and Emergency patients were determined per day of the week for each patient type. In order to calculate the service times for each patient types only those patients that go through the enter system were considered. When evaluating both the OB database and the OB PAR database to predict this number a disparity was found so it was concluded that both databases should be combined where the records were of the same patient. The patients are scheduled to arrive at a particular date and time. According to the database some patients do not arrive when they are supposed to. The table below describes the average time a patient is due according to patient type.

Table 8: Number of Patients – Elective Scheduled Patients

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Avg.	2	3	3	2	2	3	1
Std.	1	1	2	1	1	3	0

All delays were classified according to the procedure the patient undergoes. It was determined that only the service time for incision is impacted by the patient case and service type. All patients that visit the OR (*Elective Scheduled, Elective Add-on, and Emergency*) have the same service time with the nurse in the Recovery area. Extra recovery patients follow a different distribution. The distribution is impacted by the patient risk factor and service type. Patients then wait by themselves to be discharged. The distribution that this follows is impacted by case type and risk factor.

4   SIMULATION MODEL

The development of the simulation model began after the observations of proceedings within the L&D department and once the necessary data was extracted from the given database. Once the procedural operations were studied, assumptions were needed to create a simulation model that best emulated the real system's procedures in the Labor and Delivery Rooms. The following assumptions were made:

1. An elective patient with a scheduled data and initially post date in the database on the **same day** of surgery is considered an *Elective Add-on*.
2. An elective patient who is initially posted **before** the scheduled date is an *Elective Scheduled*.
3. In the database, there are two service types: *GYNGYO* and *OBGYN*. During an interview, it was decided to separate *OBGYN* by three main procedure types (with highest percent of occurrence) and one representing all other procedures performed in this department. This created a total of five service types within the model: 1) GYNGYO, 2) *BTL,* 3) *CERCLAGE,* 4) *C-SECTION, AND* 5) *OTHER*.
4. In the model, anesthesia is administered to each patient once an Anesthesiologist Attending has entered the OR.
5. Patient data was separated according to weekdays and weekends so as to not distort any input information collected for each patient.
6. Extra-recovery patients who use the L&D recovery area are considered as separate patients with their own time of arrival to the system with the same distribution for both the weekdays and weekends.
7. All Elective Add-on patients use available floor staff since they do not have their own medical team.
8. The Anesthesia Attending arrives to the OR after the patient, leaves prior to the start of incision, and returns after incision is completed. However, they may leave the patient if paged. If they leave because of this condition, they do not return until requested to come back after incision is complete.
9. The Surgeon Attending arrives to the OR prior to the start of incision and stays until after dressing is completed. However, they may leave the patient if paged.

The model represents three different processes: the process followed in the Holding Area, the process undergone within the Operating Rooms, and the process followed in the Recovery Area. Figure 2 to 4 documents the patient flow implemented in the simulation model logic.
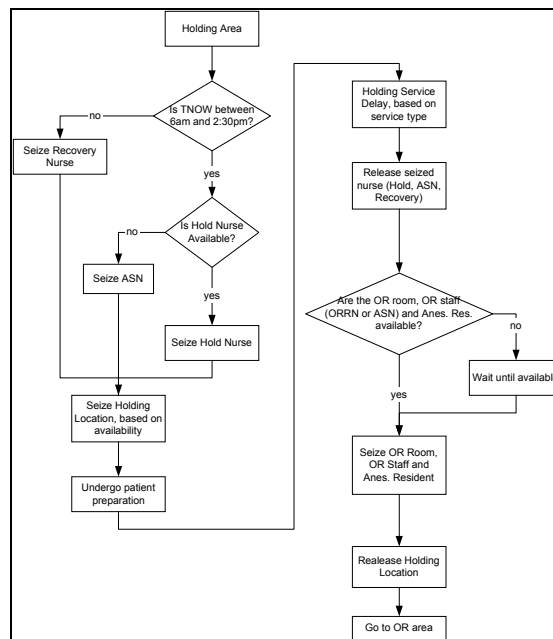

Figure 2: Holding Area

Patients arrive to the entrance of the simulation model in batches according to the rate for that specific patient type. Here it is determined if they will enter the holding area or continue on to the OB OR. If the patient does enter the holding area, they are seen by the available nurse (Hold Nurse, ASN or Recovery nurse if it is after 2:30 p.m.). Once they are seen by the nurse and all Holding preparation is completed, patients wait here until all staff and the OR is ready for surgery. If the patient is not cancelled while in the Holding area, the patient is escorted to the OR by the nurse and the Anesthesia Resident . The OR Tech is already waiting in the OR when the patient arrives. While in the OR, the patient has the possibility of being cancelled up until the point of incision. All patients must go to the Recovery area after entering the OR regardless of whether they are performed or aborted. Here the Recovery nurse process the patient and the patient awaits discharge.

Different alternatives would be affected by changes made in the simulation model with the main objective of achieving the project's goal. These alternatives were developed to study operational procedures and to make recommendations with improvements. Examples of improvements would be: patient's flow would be increased, the Labor and Delivery Rooms and the staffing utilization's would be improved, and the overall throughput would be improved. The changes made in the original model were the following:

1. Added another Hold RN, OR tech, Rec RN, and Associated head nurse just for the peak hours. Peak hours being defined as the time when patients were scheduled. Early in the morning and afternoon, it was chosen to be appropriate since most cases are seen during this time.

2. Scheduled patients throughout the morning instead of arriving all patients at 6 am. This was done to make the patient flow and staffing utilization smoother throughout the day.

The model was developed using the package ARENA. Once verified and validated, the model was run for different scenarios, and form the results the conclusions described in the next section. At this moment, the model is being used to explore other scenarios. The addition of a user interface is also being considered.
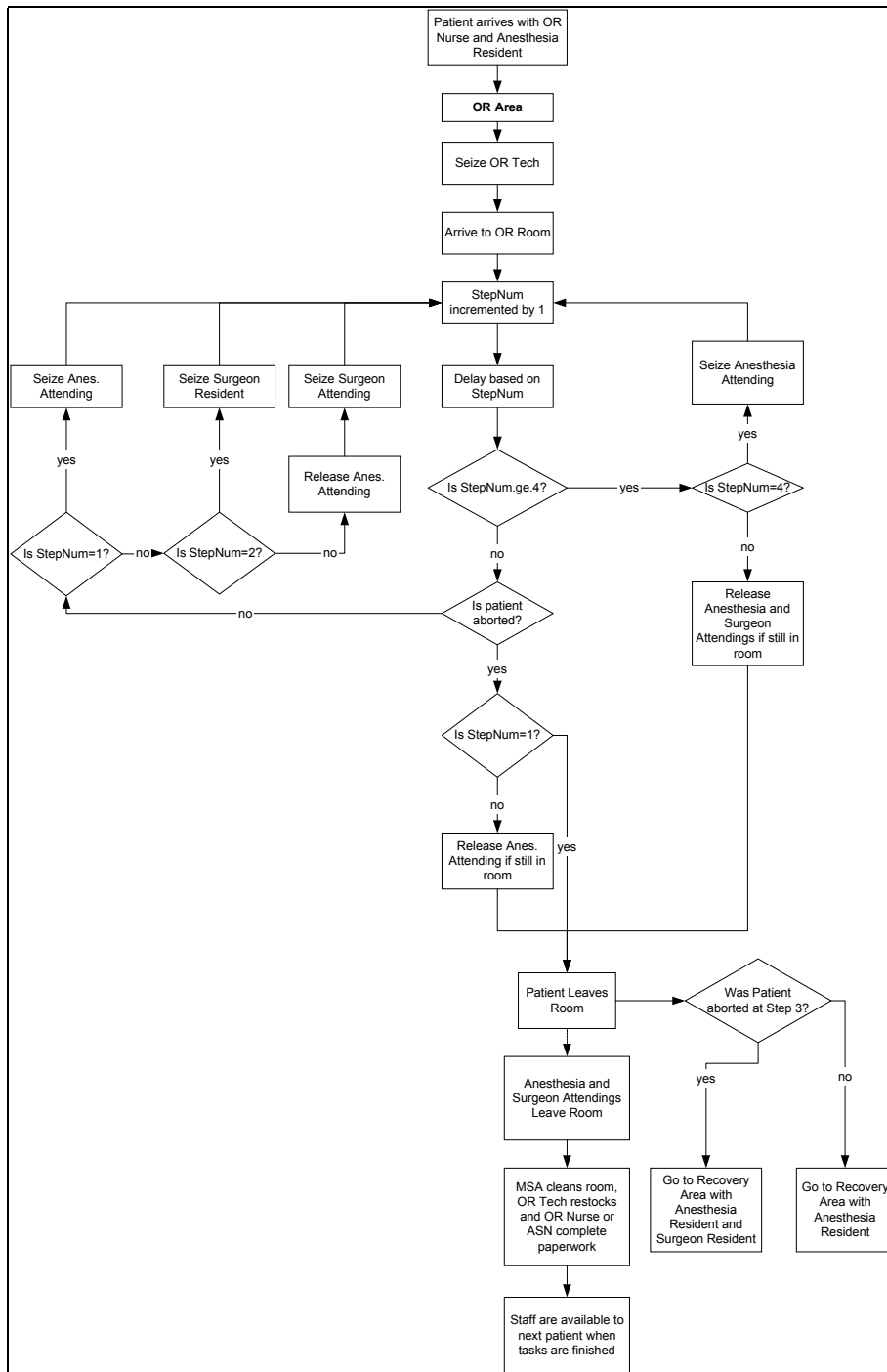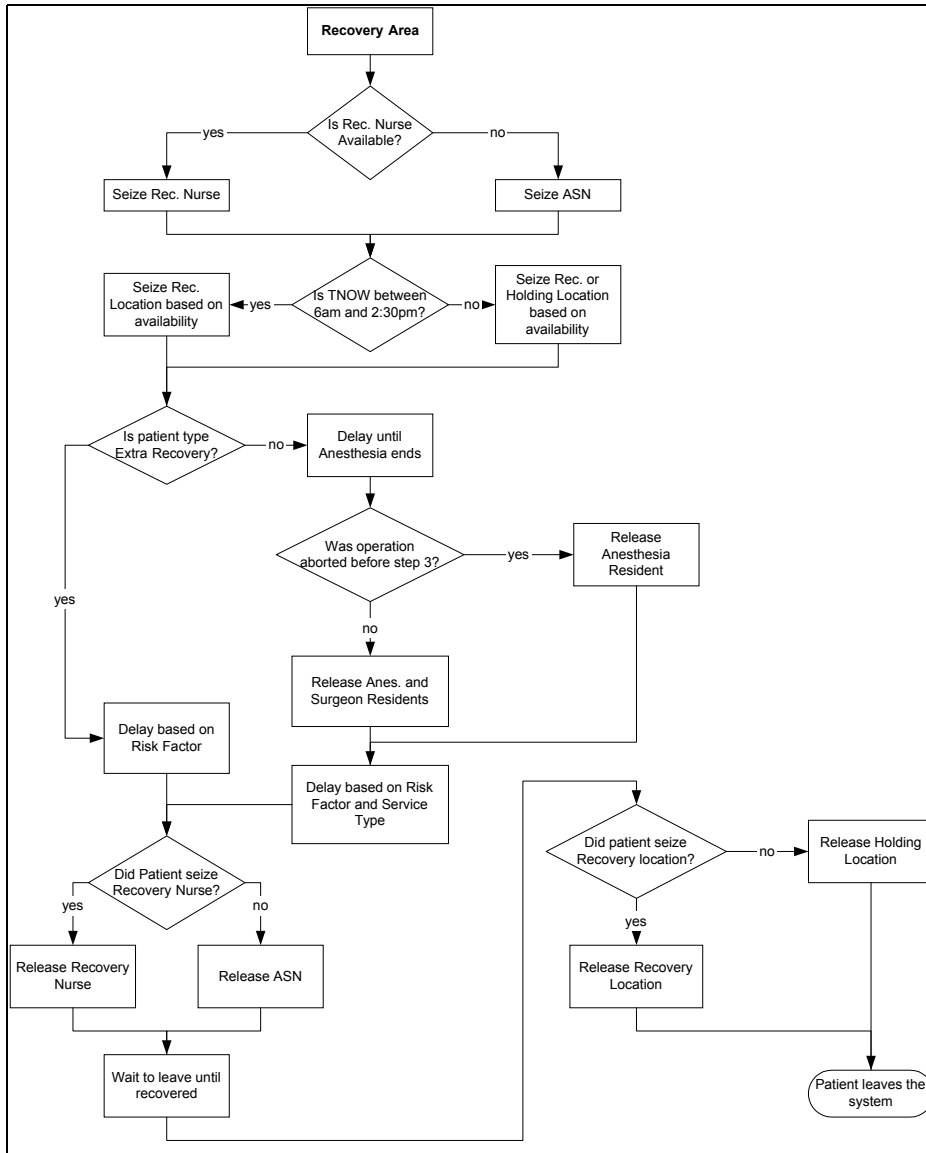

Figure 3: O.R. Logic

Figure 4: Recovery Area

5   CONCLUSIONS AND RECOMMENDATIONS

After reviewing the actual model developed, from observations, and from staff interviews the following conclusions were made:

1. Low staff availability. In the holding and recovery area there was no clerk. This made the holding nurse and recovery nurse to be inputting data into the computer instead of attending patients; therefore patients waited longer periods of time. In the OR, it was found that the associated head nurse was overloaded with work because of lack of registered nurses. Because of lack sufficient staff, the nurses worked overtime excessively.

This would turn in fatigue, decrease worker morale, and to incurred in unwanted mistakes.

2. Budget increased greatly because of overtime. Costs accounted to overtime by staffing were in part because of poor scheduling and lack of staff.

3. Lack of staffing at the Holding and Recovery area. When extra-recovery patients were sent to the recovery department, the area was faced with an overload of patients. The utilization for the Recovery RN was quite high throughout the day, but excessively high during peak times and when extra recovery patients arrived to the area.

4. Poor scheduling of room and doctors. It was observed from the database that a Doctor was scheduled for the two OR rooms for the same

time. This delayed the second patient, staff, and room until the completion of the first surgery. Doctors should be assigned to one room at a time. With a larger staff pool to choose form, the utilization of the OR rooms would increase. In the model, the rooms mostly utilized were Room 44 and Room 45, while Room 41 was hardly ever used. This was due to the lack of personnel. By adding staff, all rooms are better utilized. However, it was also considered interesting to allow Room 41 available during peak hours for emergency and add-ons patients. A doctor would not allow a co-worker to perform a surgery in a different room while he was performing a surgery because of an OR room schedule error. This made the patient wait in the holding area for a long period of time unnecessary.

5. Shortage of supplies was observed. This caused the surgery to be delayed until supplies arrived.

The following recommendations were suggested to the Engineering Management team:

1. Scheduled patients should have priority overall, except in case of an emergency.
2. Have a single input data form and a standard code system to prevent input errors in database.
3. Have staff on-call, in case of extra emergency cases when a staff member does not cover their shift.
4. Need to implement continuous improvement studies.
5. When scheduling, have consistent times of surgery. This will prevent having the same OR being scheduled at the same time.
6. If staff is not available, do not schedule all patients at 6 am. This causes excessive delays for the patients in the Holding area. Spread the schedule times throughout the morning.
7. Increase staff. Need of a clerk to be inputting data into the computer to allow the holding nurse and recovery nurse perform their tasks.
8. Continue cross training of staffing to allow other workers to cover for sick staff and prevent unnecessary delays in the increase of the available staff pool.
9. Have supplies in the OR, and Holding and Recovery area on time.

ACKNOWLEDGMENTS

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