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DISCRETE EVENT SIMULATION: OPTIMIZING PATIENT FLOW AND REDESIGN IN A REPLACEMENT FACILITY

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ABSTRACT

This study observed the challenges of taking an existing facility's inpatient volumes and procedures and projecting them into a replacement facility with differently sized units, overall scale, and layout. Discrete event simulation is used to examine the impacts of this transition as well as the operational impacts of capacity changes, process redesign, and process improvements. This effort to optimize patient flow throughout the inpatient units is done while modeling and observing the impacts on other interdependent parts of the hospital such as the Emergency Department, and Operating Rooms.

1 INTRODUCTION

1.1 Hospital Background

1.1.1 History

The current LAC+USC Medical Center functions as Los Angeles County's largest health care facility, the single largest provider of trauma and emergency services in the County with a full spectrum of emergency, inpatient and outpatient services. Medical, surgical and emergency/trauma services are provided at the General Hospital and obstetrical, gynecological, pediatric and specialized neonatal intensive care services are provided at a close proximity Women's and Children's Hospital. Psychiatric inpatient services are provided offsite at Ingleside Hospital and Hawkins. The existing facility is licensed for 1,395 beds and is currently budgeted to staff 685 beds. LAC+USC has over 6,900 employees.

1.1.2 New Construction

The Department of Health Services (DHS) is constructing a 600-bed hospital to replace the existing General Hospital and Women's and Children's Hospital while maintaining their 50 off-site psychiatric beds. A key planning objective of the County and DHS is to ensure that the replacement facility continues its core mission to function as the backbone of the County's safety net and as a major regional and community emergency/trauma and critical care provider.

The site of the replacement facility is located in the southeast area of the hospital campus. Construction excavation and other activities began in March 2003 and construction is scheduled for completion in June 2008. The new facility is expected to be fully operational in Fall 2008.

1.1.3 Vision for the Future

Planning for the new facility began ten years ago. Initial estimates for Inpatient beds were around 900 beds. The new 600-bed facility (see Figure 1) will operate as a Level I Trauma teaching hospital accommodating an average of 570 inpatients per day in addition to 49 Psychiatric inpatients (95% occupancy), a reduction from current average daily census of 640. The facility will have a higher proportion of ICU beds than the present hospital, resulting in an overall higher patient acuity.

Figure 1: LAC+USC Replacement Facility

The new facility will operate as a tertiary-level medical center in four (4) buildings with a 600-bed inpatient tower, a diagnostic and treatment services center, an outpatient specialty services clinic, and a central plant. The current space allocation for the replacement facility is 1,469,565 square feet.

1.2 Process Challenges

1.2.1 Current Services

LAC+USC provides services not available at other County or private hospitals. In Fiscal Year 2005-06, emergency visits exceeded 150,000 and outpatient visits exceeded 530,000. LAC+USC provides the following services:

- Operates one of three burn centers in the County
- Operates one of the few Level III Neonatal Intensive Care Units in Southern California
- Cares for half of the patients tested positive for HIV and half of the sickle cell anemia patients in Southern California
- Maintains inpatient and outpatient services for the most acute cases of mental illnesses

LAC+USC is also a teaching hospital, training approximately 1,500 medical professionals per day, including more than 860 medical residents in nearly all medical specialties, 160 students for nursing and other health professions such as pharmacists, midwives, occupational, speech and respiratory therapists, dieticians, podiatrists, and laboratory and radiology technicians.

1.2 Inpatient Facilities

The new facility is being designed with higher acuity beds which should allow for great accommodation of higher acuity patients and flexibility for patient placement. The knowledge of how today's operations and volumes will translate into the new facility is uncertain. Multiple inpatient units are being downsized and combined with others while some are being expanded. These factors create a great degree of uncertainty about how the hospital will function once the new facility is opened and thousands of patients enter their doors.

2 SIMULATION APPROACH

2.1 Project Scope

The core of this project laid in the detailed process mapping of the inpatient units and the activities required to treat and process patients. Every major activity in the inpatient process, from a patients arrival to their discharge was included in the model. However, the inpatient units are far from an independent system as they rely heavily on other departments for their patient volume and support services to process their patients.

In order to accurately model the external influences that impact the inpatient floor of a hospital multiple factors needed to be taken into account. First, was the ED whose volume varies greatly throughout the day and year, and routes almost one fifth of their patients to an inpatient bed. Secondly, the OR, demands a different mix of inpatient beds at different peak hours than the ED. Additionally, other admit sources such as direct admits and transfers were grouped together to form a third stream of patients demanding inpatient beds. Lastly, support services such as radiology and lab were modeled to reflect historically accurate turn around times. A snap shot of the model's animation can be seen in Figure 2.

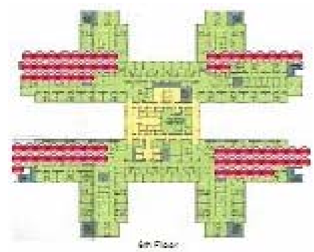

Figure 2: Model Animation

2.2 Key Metrics

A primary goal of this project was to enable the hospital to optimally place patients in the unit that best suits their level of acuity and to do so in a timely manner. Patients are frequently transferred between units in the facility based on their changing acuity and medical needs. The ability to transfer is not always possible due to bed shortages. To monitor this impact the number of patients who were able to be transferred to an ideal inpatient bed was tracked as well as the wait time for each source of patients. Figure 3 shows a patient transfer matrix where the ideal location transfers are the diagonal, and the secondary location transfers are the other colored cells. Ideally, patients would be transferred to the appropriate primary location, the diagonal, but due to high utilization, patients are routed to other bed units.

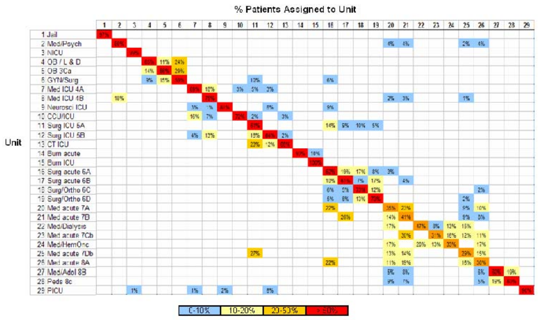

Figure 3: Patient Transfer Matrix

Tracking the routing of patients and their subsequent wait times served not only to display the impacts of different scenarios, but also as a validation point when compared to previous modeling attempts (Miller, M. et. al 2007) and historical data.

Additional metrics included utilization of each bed type, length of stay (LOS) measures for both the ED and OR, as well as average daily census (ADC) for each unit. A view of the spreadsheet used to capture model output can be seen in Figure 4.

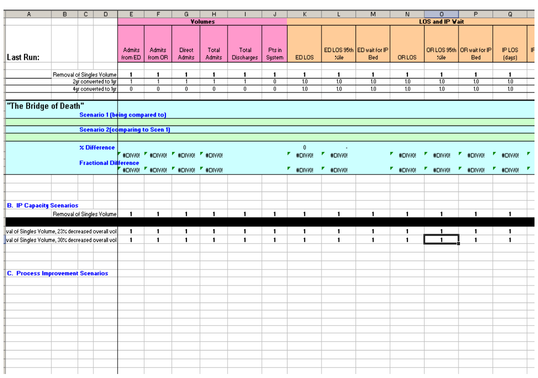

Figure 4: Key Metrics Model Output

2.3 Experimentation

2.3.1 Capacity and Volume

Given the facility being modeled is not yet built and is smaller then the existing one, expected volumes and demand could only be estimated from historical numbers. This ambiguity called for experimentation to determine the correct number of total and specialty inpatient beds.

Capacity related experimentation also looked at indirect means of increasing bed availability. The effects of implementing best practices such as early discharge time of day, earlier physician rounding practices, and enhanced use of conditional orders were determined through multiple scenarios.

2.3.2 Process Changes

Some of the more conspicuous opportunities for improvement in inpatient care were centered around the discharge time of day, bed management and transfer processes. Specifically, use of discharge lounges, centralizing bed management, and reducing the number of internal transfers were identified as mitigation strategies for LAC+USC. Internal transfers were of interest, as some patients were transferred up to seven times during their stay.

Other, less effective, process changes included: reducing the number of physician interventions, reducing bed turn around time (TAT), and increasing the use of point of care testing (POCT) for lab tests. Numerous other best practices were evaluated.

2.3.3 Process Improvements

Multiple scenarios also scrutinized the impacts of decreasing turn around time and length-of-stay durations for longer activities. Activities like radiology, lab, transport and even inpatient length of stay were all examined with multiple simulation runs and sensitivity analysis. The effects of streamlining discharge and admit processes were also observed and evaluated.

2.4 Challenges

The largest challenge in the project was ward mapping efforts that had to occur to create the model. The new facility has less capacity than current volumes (640 current census vs. 600 new beds) and almost half as many units (48 vs. 26 wards), as the old facility. Extensive work was done with hospital physicians and administrators to determine how the current patient mix would be allocated in the new facility. Further effort was required during the experimentation stage to determine what changes in bed allocation and placement were clinically feasible to use in the scenario analysis.

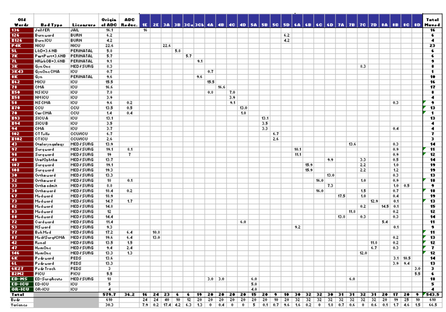

Figure 5: Ward Mapping Matrix

3 RECOMMENDATIONS AND FINDINGS

Changes that needed to be made at LAC+USC were overshadowed by the changes that could not be made. In some scenarios that limited the amount of inpatient beds that the ED could admit patients to, the ED's wait time for IP beds more than doubled, which causes delays in the Emergency Department at the waiting room level. This however was not entirely unexpected given previous modeling efforts (Miller, M. et. al 2007).

Positive results were most prominent when volume levels, the number of transfers, and restrictions on beds were reduced. Utilizing documented best practices like the use of discharge lounges and refusing to admit operating room patients before the day of surgery were found to dramatically decrease the utilization of many inpatient units.

The largest positive impact was made when the inpatient units were combined within the new facility to create fewer, less specialized units. The removal of specialization allowed for larger groups of beds and fewer transfers, which in turn decreased wait time for a bed and decreased the overall inpatient LOS. This added flexibility in the process had a dramatic and positive impact on the flow of patients.

4 SUMMARY

The challenge of transitioning a hospital which houses an average of 640 patients into a new facility with a total of 600 beds would appear at first glance to be impossible. With the use of discrete event simulation and the input from administrators and clinicians, the task of condensing patient volumes and duration of stays makes the task difficult, but not impossible. By decreasing the non value added procedures like excessive transfers, and decreasing patient's LOS by using best practices like conditional orders, the hospital will be able to function in their newer, but smaller, facility.

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