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MAXIMIZING HOSPITAL FINANACIAL IMPACT AND EMERGENCY DEPARTMENT THROUGHPUT WITH SIMULATION

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ABSTRACT

Carondelet St. Mary's Hospital (Tucson, Arizona), the Ascension Health Operations Resource Group and FDI Simulation team worked collaboratively to improve hospital flow and increase access to care by implementing process improvements based on simulation that reduced the Emergency Center (EC) length of stay by 7%, increased the EC monthly volume by 5%, increased the inpatient daily census by 20% and improved the hospital net operating margin by 1.3% above budget. This paper demonstrates simulation's unique ability to direct improvement efforts for maximum impact operationally, financially and for the best benefit of the patient.

1 EMERGENCY DEPARTMENT BACKGROUND

1.1 Simulation Advantages

Simulation is a state-of-the-art tool for process analysis. It analyzes the behavior of either real or imaginary systems over time. Simulation is usually performed on a computer using either off-the-shelf or customized software. Simulation's main capability is to analyze what-if scenarios, especially those proposed in Emergency Departments (Miller, Ferrin, and Szymanski 2003). Also, simulation is one of the most widely used analytical techniques used by professionals in Operations Research and Management Science (Law and Kelton 1991).

Computer simulation has existed for almost 40 years and has been used in every industry to study systems where there are resources at locations acting upon people or products (Nance and Sargent 2002). A few examples of simulated systems are manufacturing plants, banks, airports, or business organizations (Ferrin, Miller, and Giron 2000).

There are several methods to study an Emergency Department and determine the impact of changes. The most direct way is to experiment on the actual system. This might involve testing a change on a small part of the ED for a short period of time and then collecting statistics to quantify the impact. Alternatively, we could build a mathematical model of the ED, either as an analytical solution or simulation (Law and Kelton 1991). Simulation is more effective than analytical solutions for complex models, where the state of the system changes over time. In fact, an analytical solution may not be possible as system complexity increases. Emergency departments are considered one of the most complex systems to analyze.

1.2 EDsim Product

Simulation has been successfully used to model and analyze numerous emergency departments around the world (Mahapatra et al. 2003). FDI Simulations (FDI) has developed a semi-reusable product, EDsim, to quickly model and test alternative design scenarios for existing and proposed hospital emergency departments. This product is the result of a basic need by hospital administrators to improve Key Performance Indicators (KPIs), such as patient length of stay (LOS), bed utilization, elimination of bottlenecks, etc. EDsim is also ideal for predicting performance of proposed emergency departments before finalizing architectural designs. Hospital administrators not only hope to avoid the same problems they currently face, but proactively eliminate new problems associated with opening a new ED.

Examples of the kind of answers which the EDsim product has yielded to hospital executives include (Miller, Ferrin, and Szymanski 2003):

- Discharging inpatients about five hours earlier each day reduces ED patient LOS by a third,
- Adding 30 more inpatient beds will potentially cut the ED patient LOS in half,
- Reductions in lab test turnaround time won't significantly affect overall patient LOS until it is reduced by at least 20%,

- The new ED only needs two-thirds of the proposed beds currently being designed (which will save millions of dollars),
- The new ED will handle up to 65,000 patients annually before ED LOS becomes unacceptable,

FDI's EDsim product was developed to be user friendly and client transferable. Since every ED is different, EDsim can switch on and off activities and functionality. Customization and consulting usually accompanies the product. This remainder of this paper will discuss how to more efficiently complete an EDsim project by reducing the time and effort associated with experimentation.

2 PROJECT APPROACH

2.1 Objectives

A project begins with well defined objectives. Simulation project objectives for an ED will typically include

- How can the hospital capitalize on the project growth of patient arrivals in the next 3-7 years?
- What process improvements will improve patient LOS, particularly when hospital volumes increase?
- How can the ED mitigate the frequent problem of a lack of ED beds?
- How many beds should the new ED construction include? How many years of projected growth will this accommodate until more construction is needed?
- How does the lack of inpatient beds impact the ED?

Understanding, meeting and exceeding specific client objectives will ensure a successful project. The phases of a simulation project usually include

- Development of a conceptual model
- Programming the simulation and user interface software
- Testing the software
- Experimenting with specific scenarios,
- Presenting the results to project stakeholders.

Ultimately, the answers that a simulation model provides should tell a story. This is especially important when presenting results to executive management. A common mistake when presenting results is to overwhelm the audience with data. Although much effort and pride accompanies this data, it is wise to summarize results into a limited number of slides. Composing the answers graphically will help the audience view the recommendations as a journey into the future.

2.2 Modeling the ED

It is often useful to build a model when trying to understand a system. Engineers and managers usually study a system to gain better understanding of how their processes work and find ways to improve operational performance or design, if it doesn't exist yet (Miller, Pulgar-Vidal, and Ferrin 2002).

Similarly, it is always useful to design a product before construction (e.g., architectural blueprints of a building). An emergency department simulation begins with a conceptual model. A conceptual model is more than just a process map, or flowchart, however (see Figure 1). There are detailed descriptions and business rules which accompany the objects on a process map. This information is best stored externally which improves readability of the process map and doesn't visually overload it.

FDI's approach to building a conceptual model involves process modeling workshops, interviews with subject matter experts (SMEs), and data collection. Whenever possible, build off previous flowcharting efforts, which avoids 'reinventing the wheel' and reduces project time and costs.

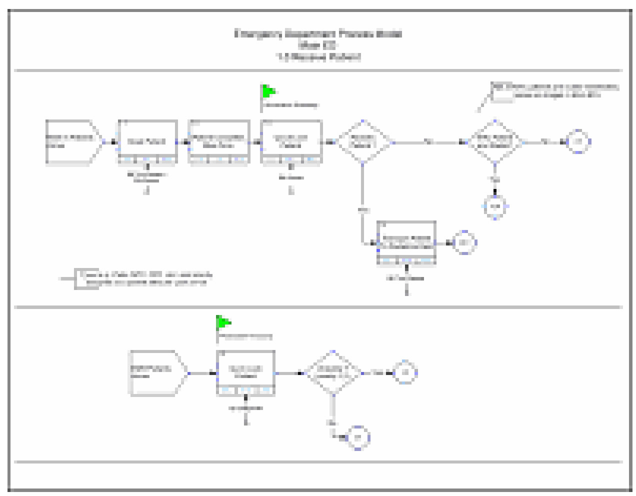

Figure 1: Conceptual model for ED simulation

Also, the conceptual model provides a useful interim deliverable and a way to control scope. Changes to the model are more expensive as the project progresses, so it is important to obtain stakeholder sign-off of the conceptual model before continuing with programming. The conceptual model is also useful even if no simulation model is constructed. Building a conceptual model helps increase the understanding of a process which no single individual may possess knowledge of. Staff can now see the 'big picture' of a process and better understand how their contribution impacts the end result.

2.3 Assumptions

Adding more complexity to the emergency department model doesn't always add value to the final analysis. In fact, too much complexity is counterproductive because more time and effort are involved with ensuring validity (the model behaves like the real system). Also, the data available may not apply to the level of model detail. For example, actual data to process lab orders may only exist at an overall high level and not for individual activities. As a result, the process model should reflect a single activity for processing lab orders. The goal is to find the right level of complexity which allows you to meet project goals (see Figure 2).

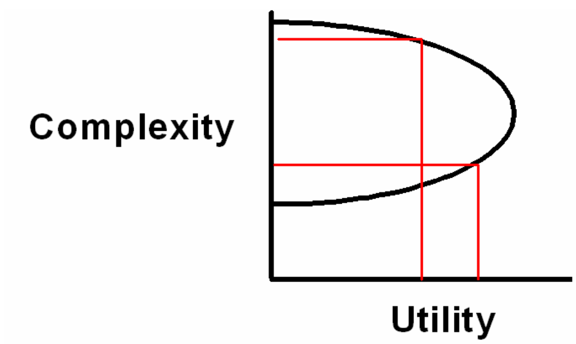

Figure 2: Utility curve for model complexity

Making valid assumptions simplifies the model and allows the project team to control scope and proceed efficiently. Typical emergency department assumptions may include:

- ED is open 24/7
- Equipment (e.g., IT system) does not breakdown
- No catastrophic events occur (e.g., terrorist attack)
- Sufficient parking space available for all EMS arrivals
- Sufficient waiting space available for patient's family

2.4 Scenarios

Scenarios are defined and documented before beginning experimentation runs. Usually, scenarios are discussed with the client early in the project lifecycle, while discussing goals and expectations. Supplementing this list with other industry best practices helps to exceed client expectations. Grouping scenarios in the following hierarchy will be instrumental when executing scenarios and finding the best alternatives:

1. Arrival volumes
2. Inpatient beds
3. Ratio of main ED and FastTrack beds
4. Process improvements

For example, arrival volume scenarios may include current volumes as well as projected volume, incremented in 5,000's. Inpatient bed scenarios may include current numbers as well as future available beds, incremented in 24's. Also, the ED may only have so many beds, so there are different scenarios to test the ratio of main ED beds and FastTrack beds (see Section 3.3). Process Improvements as well as best practices (such as skipping triage when an ED bed is open) may be tested individually or in combinations.

FDI's EDsim product includes a graphical user interface, a.k.a. Control Panel, which allows the simulationist to quickly create scenarios and capture results (see Figure 3). Despite this tools usability, an algorithm is necessary to efficiently harvest the valuable results from the simulation model. This algorithm should eliminate unnecessary or redundant scenarios which don't add value.

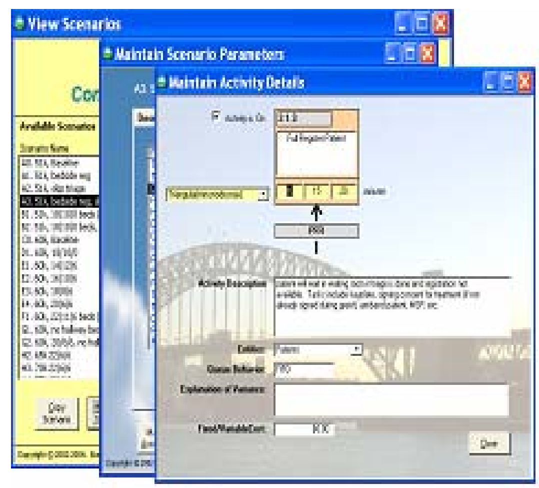

Figure 3: EDsim Control Panel

Each alternative should be tested individually so that simulation results are attributed to that particular modeling change. Hundreds of scenarios can exist, considering the various scenario alternatives possible. Executing and recording every permutation may be difficult or impossible.

3 EXPERIMENTATION APPROACH

3.1 Recognition of the Need for Change

Carondelet St. Mary's Hospital is a 393-licensed bed acute care hospital sponsored by the Sisters of St. Joseph of Carondelet, and a member of Ascension Health. St. Mary's is one of three hospitals comprising Carondelet Health Network located in southern Arizona. Two of the hospitals are located in Tucson at opposite sides of the city, and the third is located in Nogales at the Mexico border. Each hospital has an on-site Chief Executive Officer (CEO) and Chief Nursing Officer (CNO) who are members of the network senior leadership team led by a corporate CEO. Other leadership team members include network executives for the support services of human resources, quality management, finance, legal, physician services and information systems. One board of directors governs the two Tucson hospitals. Quality oversight is a function of the board. The senior leadership team and board were equally concerned about the ED overcrowding.

Emergency department redesign as well as other work to increase staffed bed capacity in the hospital had been undertaken with the involvement of staff from the respective areas. EDsim accurately showed that the hospital could successfully implement a No-Divert policy. The simulation showed the impact financially to the hospital and showed the community impact of the No-Divert policy through increased service. An earlier recommendation to form a process improvement team was born from line staff and their managers in response to observations they made. Together leadership and staff could see that although gains were made through innovations, deeper change was needed. The group recognized this work would take a large scope project, and therefore decided planning was needed at a senior leadership level to include the Carondelet Health Network CEO, and each of the hospital CEOs and CNOs. Strategies planned to improve the likelihood of successful change included the decision of senior leadership to make this a network priority performance improvement project. This would ensure the commitment of resources.

3.2 Development of Code Purple Plan to Prepare for No-Divert Pilot

The hospital team was primed for this pilot due to the work that had already occurred in Phase I which was directed by the simulation. The team started working on a plan named Code Purple to prepare for the citywide pilot. The Code Purple Plan outlined a hospital-wide call to action to manage the ED volume surges. Each participating department was empowered to develop its own departmental action plan for the Code Purple situations. This provided a sense of ownership for the department staff. The plan calls for resources to be rerouted from various departments to the ED when the ED beds are full, and patients continue to present to the ED. All department plans were compiled into a hospital-wide document that was distributed throughout the organization.

3.3 Fix the Inpatient Constraints

FDI's experimentation algorithm begins by removing space-related bottlenecks from the end of the process and moves bottlenecks forward to the process beginning. The algorithm then introduces process improvements to ultimately find the best scenario combinations.

For example, at a given arrival volume, the capacity constraints are solved first. This assumes that the new hospital facility can change its bed availability. The hospital can add more capacity by increasing beds and/or staff. If capacity constraints are fixed, then proceed to the next category in the algorithm by testing the ratio of Main ED beds to FastTrack beds. These beds are upstream in the ED process relative to the inpatient beds. Finally, individually test various best practices and process improvements. These improvements may occur anywhere in the process.

Bottlenecks in the process occur when the number of entities surpasses the system's ability to store and process them. For hospitals, this means there are not enough beds or staff to move the patients through from arrival to discharge. Removing bottlenecks means adding more beds, adding more staff, or improving the process to move patients more quickly through the process. Reducing the number of patients will also remove bottlenecks, but to hospitals, that means lost revenue.

Inpatient beds are used by patients who stay overnight or longer. Emergency Department patients whose condition is severe enough to require admission to the hospital are eventually taken from an ED bed to an inpatient bed. Many hospitals keep a Transitional Stay Unit, or buffer area, which is used to hold patients waiting for an inpatient bed without tying up an ED bed.

The inpatients are an inextricable part of the overall ED process. EDsim models the inpatient arrivals from the ED and from other sources, such as direct admit. Bottlenecks in the inpatient beds occur when the arrival volume exceeds the capacity. This can impact the ED by making admitted ED patients stay in an ED bed while waiting for an inpatient bed.

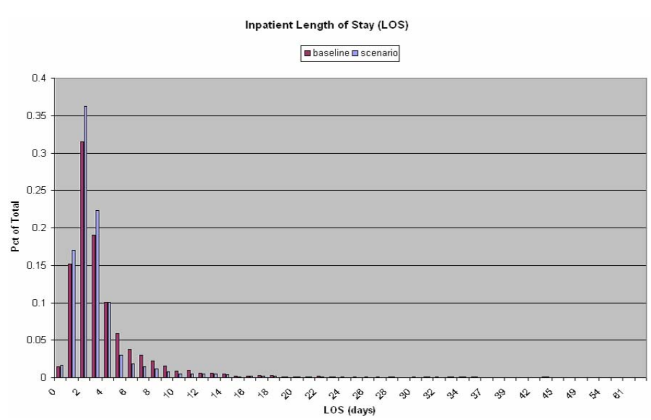

Figure 4: Empirical distribution of inpatient length of stay

The first alternatives to test are the addition of inpatient beds to see if a bottleneck exists here. Experience shows that removing inpatient bottlenecks have the largest effect on improving the ED. Continue to add more inpatient beds until there is no improvement in results. Revisit this optimal bed level later to see if it can be reduced further, particularly if process improvements are introduced. For example, one improvement opportunity for evaluation is the inpatient discharge time of day (see Figure 5).

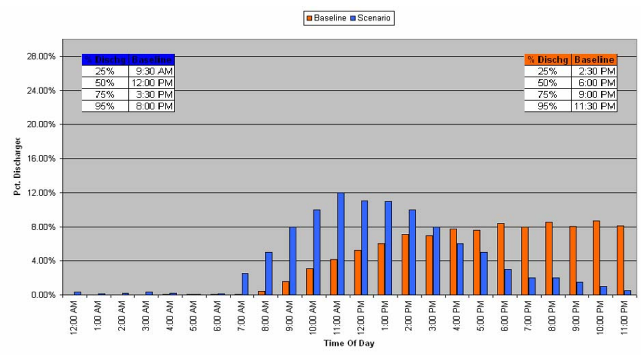

Figure 5: Inpatient discharge time of day alternatives.

EDsim tracks numerous Key Performance Indicators for each simulation experiment, including the mean and 95th percentile for ED patient length of stay. The 95th percentile is important because it can indicate how much variability there is in the process. Reducing variability will improve process efficiency, through put, costs and generally lead to improvements in patient satisfaction.

3.4 Fix the ED Constraints

Patients arrive to the emergency department either by walking in or by EMS (ambulance). Generally, the process involves:

1. Triage
2. Registration
3. Placement in an ED bed
4. Assessment
5. Completion of orders
6. Diagnosis, and
7. Disposition

The patient disposition is either discharge to home or admission as an inpatient. Constrained ED resources include beds and staff. Bottlenecks in the ED occur because the patients arrive at a rate faster than they can be dispositioned. Determining how to eliminate the bottleneck is complex and usually involves testing many scenarios.

The first step is to test scenarios where the beds and staff are increased. Test by incrementally increasing these resources until no improved results are achieved. Note that implementation of process improvements may allow further reduction in resources, making this algorithm an iterative process. Many hospitals include a small number of FastTrack beds for patients who only require minor treatment. FastTrack beds have a higher turnover rate, thus resulting in a shorter length of stay for a large number of patients. Determining the right mix of Main ED and FastTrack beds is important so that the limited number of beds is best utilized.

Testing the ED Constraints before fixing the inpatient constraints can waste time if the inpatient beds are overutilized. Consider the scenario where a large number of patients waiting to be admitted are tying up ED beds. Optimizing the ED would mean including a large pool of beds primarily used to hold these admitting patients. Subsequently adding more inpatient beds to remove the inpatient bottleneck would eliminate the need for that pool of ED beds to hold admitting patients. Therefore, the ED is now oversized and another iteration of optimizing the ED beds is necessary.

Conversely, testing the inpatient constraints before fixing the ED constraints may require another iteration if the ED is undersized. Experience shows, however, that most emergency departments actually do have enough beds and perceived shortages are a result of insufficient inpatient beds or process inefficiency.

3.5 Introduce Process Improvements

The final category of our experimentation algorithm focuses on process improvements, now that an iteration of capacity optimization has occurred. Examples of process improvements include:

- Bedside triage
- Bedside registration
- Reducing lab or radiology turnaround times
- Moving the inpatient discharge time earlier in the day
- Streamlining admitting activities
- Eliminating handoffs in the process
- Eliminating non-value added activities

The purpose of these improvements is to reduce the time patients spend in the emergency department waiting for care.

Simulation is a powerful tool for hospitals to understand how much impact each process improvement will have on their facility. Too often, hospitals assume they should automatically implement industry best practices. What works at one hospital may not work at another, which can waste time, effort and political capital.

Implementing process improvements in the model may cause bed over-capacity or under-capacity. Sensitivity analysis of the inpatient and ED beds will show if that is true. Sensitivity analysis includes making small incremental changes to input parameters (e.g., inpatient beds, ED beds) and seeing if makes a significant impact on the outcomes.

This algorithm of fixing the inpatient beds, ED beds and testing process improvements can e repeated for each arrival volume scenario. Thus, the simulation model identifies the best alternatives from a limited number of experimentation runs.

4 EXPERIMENTATION RESULTS

The ‘current’ situation at the beginning of the work was as follows:

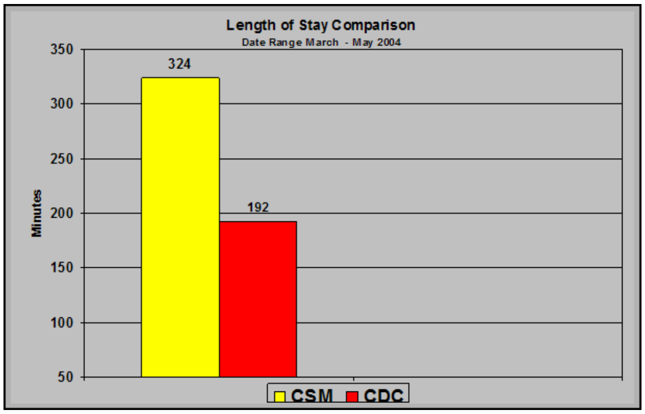

Figure 6: LOS comparison

- The LOS was 324 minutes or about 5 and a half hours,
- 68% of the hospital admissions enter via the ED,
- 25.5% of total ED volume is admitted to the hospital.
- Leave Without Being Seen rate (LWBS) hovered around 7.2%. This is 3,360 patients LWBS annually.

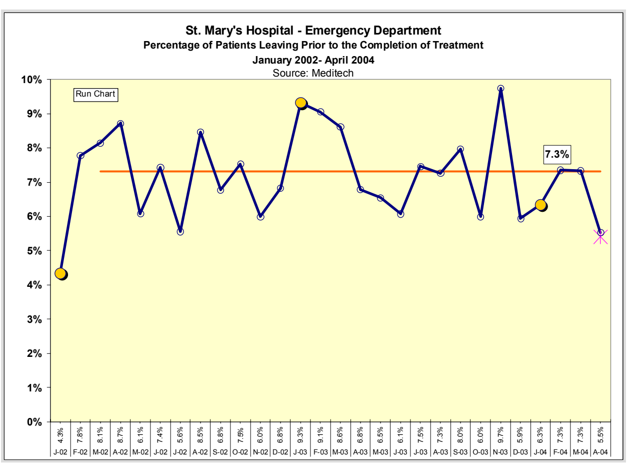

Figure 7: ED LWBS.

As directed by the model, the CSM executive team led initiatives to improve hospital throughput including the following:

1. Developed an Express Admissions Unit (EAU) with a two-fold purpose
    a. Provide care to post-procedure patients
    b. Decompress the ED of boarding patients
2. Made improvements in the admissions process
3. Improved ED arrival to triage time to less than 5 minutes
4. Adjusted housekeeping staffing patterns to match admission and discharge times

The first phase of implementation included:

- Interviews:
    - Formal and informal
    - 20 Physicians
    - Directors, managers and staff from all departments
- Observations:
    - Front-line observing flow, patterns and collecting data
    - Shadowing physicians on patient rounds
- Simulation Modeling:
    - Dynamic depiction of facility
    - Testing hypothesis before making recommendations
    - Conducting process modeling workshop

Phase-I was an extension of previous improvement work. The Ascension ORG group facilitated the effort, while Carondelet St. Mary’s staff maintained ownership. Team conducted over 150 scenario runs, evaluated “As-Is” and “To-Be” scenarios, identified capacity requirements, identified best ED and Inpatient bed complement, determined the impact of volume fluctuations, bed control processes, changed triage processes, improved ancillary Turn Around Times (TAT), evaluated the application of an ED Discharge lounge and moving the inpatient discharge time earlier in the day.

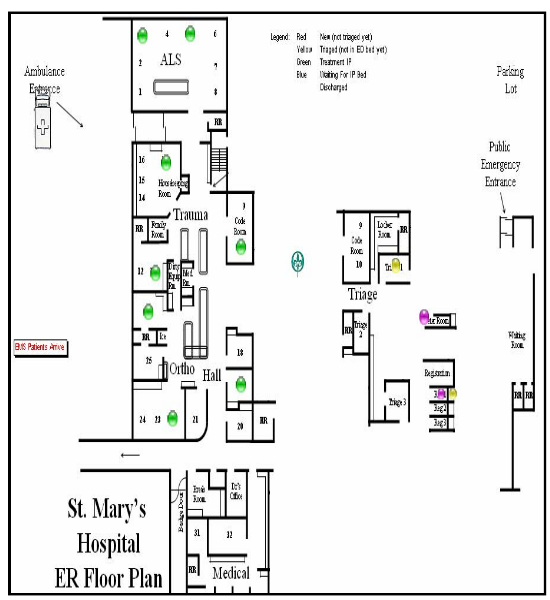

Figure 8: The ED model animation.

The first finding identified current inpatient bed capacity.

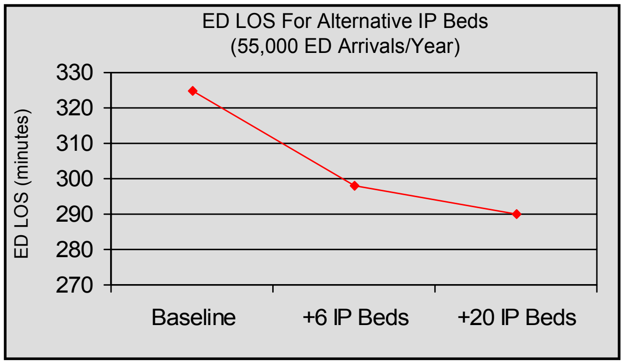

Figure 9: Additional inpatient bed's impact on ED LOS.

This finding (Figure 9) showed the impact additional inpatient (IP) beds had upon the ED Length Of Stay (LOS). Six additional IP beds, which were being blocked, reduced ED LOS by 8% from 325 to 298 minutes.

The second finding showed that radiology improvements did not improve ED LOS. Whereas, the third finding, that laboratory improvements demonstrated a modest 3-9% gain in overall patient LOS. The next finding, showed that a small six bed Fast Track unit in the ED helps throughput reducing ED LOS roughly an hour.

Other findings were as follows:
-Bypassing Triage when an ED bed is available combined with Bedside Registration showed average Time from arrival to get an ED Bed and Time to Doctor improve dramatically. This decreases overall LOS by 7% (20 minutes) and the time the ED is at full capacity reduces 37%.

An ED Discharge lounge should be opened when the ED occupancy is >85%

These findings lead to multiple changes, process measures and goals including the following:

- Implemented a Mobile Admissions Team
- Developed a Centralized Bed Control Process

New outcome measures included:

- Leave Without Being Seen (LWBS) rate with the goal to decrease ED LWBS to 3.5%
- ED Patient LOS with the goal to reduce ED LOS to 192 minutes
- Percent of Direct Admits Accepted with the goal of 100% Requested Admissions will be Accepted
- Diversion hours with the goal to reduce diversion hours from over 100 hours per month to zero.

5 CONCLUSIONS

During the first few months of implementation, all operational process measures improved dramatically. The hospital successfully began the no-ambulance-diversion processes a month earlier than the city's request.

CSM received significant financial impact from the no–diversion policy not only in the ED but also in inpatient areas. The LWBS improvements similarly received significant financial impact in the ED and inpatient areas since nationally 3-4% of patients that leave without being seen should have been admitted. Amidst all this effort, the ED also successfully implemented staffing improvements.

Much of the impact was achieved within the first three months of implementation. CSM executive management credited this impact to the simulation effort since the simulation showed the teams where to go, how much to improve and what not to improve.

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