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IMPROVING PATIENT FLOW IN A HOSPITAL EMERGENCY DEPARTMENT

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ABSTRACT

Hospital emergency departments in the US are facing increasing challenges due to growth in patient demand for their services, and inability to increase capacity to match demand. We report on a new approach to patient flow in emergency departments, and a simulation model of the approach. Initial results from the model show that the approach is feasible, and a pilot study demonstrates substantial improvements in patient care.

1 INTRODUCTION

Hospital-based emergency care in the US is experiencing significant challenges. The number of hospitals and emergency departments is decreasing while demand for care is increasing rapidly (Committee 2007). Symptoms of this demand-capacity mismatch include emergency department (ED) crowding, ambulance diversion, and boarding of admitted patients due to lack of hospital beds. Most patients experience very lengthy waits before receiving care, and some leave without being treated.

Because of the variability caused by unscheduled arrivals, simulation is widely used for analyzing many different approaches to ED process improvement (Samaha et al. 2003, Ferrin et al. 2007). Simulation has been used as an adjunct to six sigma programs (Miller et al. 2003) and for evaluating ED schedules (Centeno et al. 2003, Ashby et al. 2007). Facilities improvements have also been tested using simulation models (Wiinamaki and Dronzek 2003, Gibson 2007).

A major focus of ED process improvement efforts is optimizing patient flow to reduce waiting time. “See and treat” is a popular approach in the UK (NHS 2004), and in the US many hospitals have implemented “fast-track” systems (Rodi et al. 2006; Sanchez et al. 2006). Fast-track systems (and some implementations of see and treat) create a separate staffed area for care of patients identified as low-acuity at triage. Mahapatra et al. (2003) simulated an ED to identify the best operating hours for a fast-track unit, and Davies (2007) compared two approaches to see and treat via simulation.

We are developing and implementing a new approach to patient flow in the ED. Provider Directed Queueing (PDQ) places an emergency care physician at triage. The emergency care provider listens to the patient’s complaint and the triage nursing assessment and works as part of a team to provide the resources necessary for patient care. For example, the provider may conduct a medical evaluation, order diagnostic tests, or, if a bed is available and needed, send the patient to a traditional ED room.

Simulation provides a means to estimate resource requirements, patient census and patient waiting time when the new approach is in place. Results from the model and a pilot study have influenced the design of a new addition to the Hershey Medical Center ED.

2 PATIENT FLOW IN PDQ

Figure 1 is a high level illustration of patient flow in the PDQ process. Upon arrival at the ED, critical patients are immediately assigned a room. All other patients complete a mini-registration process (not shown) in which they provide their name, address, and chief complaint. Following mini-registration is a triage station. The PDQ provider listens to the triage nurse assessment. The provider will then take primary responsibility and definitively disposition for minor emergencies. The PDQ provider works with a charge nurse and an emergency department technician as needed in providing patient care. The ED has capability to perform some diagnostic procedures for these patients, while others (e.g. X-rays) require use of an outside lab. In some cases, these patients may require treatment in a traditional ED room, but many can be discharged without using a room. The discharge process is followed by checkout (not shown) which includes complete registration and insurance verification or payment.

If appropriate clinical care space is unavailable for patients who need urgent care, the PDQ provider will initiate care orders as dictated by complaint, passive hearing

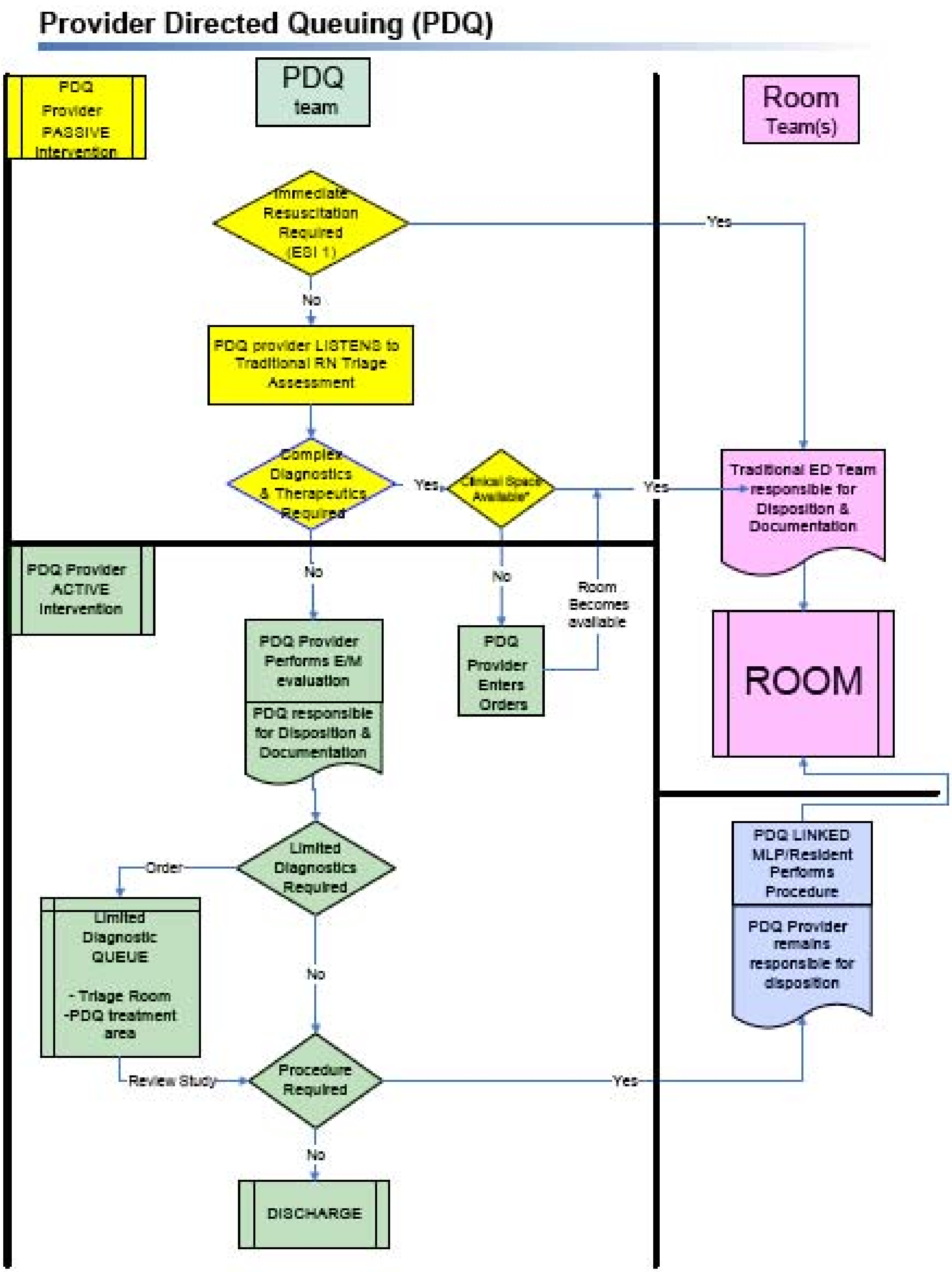

Figure 1: Flow of patients in Provider Directed Queueing Process

of nursing evaluation and initial personal evaluations. In many cases, the patient will be moved to a laboratory external to the ED for tests; this is reflected in the figure as complex diagnostics. This reduces waiting time for lab work once the patient is assigned a room.

The main ED functions in the traditional manner, providing care for patients who need those resources. It is staffed by 1 or more teams as needed. The PDQ team includes a physician or physician assistant, a triage nurse, a charge nurse, and an emergency department technician. There are also 2 administrative clerks, one for mini-registration and one for checkout.

The PDQ process will operate during the busiest part of the day. At other times, patients will flow through the traditional ED process.

3 SIMULATION MODEL

The model was built in Arena (Kelton et al. 2007), starting with the flow diagram of Figure 1 and elaborating the specific tasks required at each step. Modeling objectives included estimating patient census, patient length of stay, and utilization of the PDQ team members. In this section, we discuss some of the issues that arose in modeling the system and how we resolved those issues. The major modeling issues related to human activities, particularly teamwork and decision-making, as well as modeling the operations external to PDQ, including laboratories and the main ED. The chief difficulty in analysis came about because of the transient nature of this system and the considerable changes in arrival rates during the day.

3.1 Modeling Human Activities

We did not attempt to capture the PDQ provider's decision making on which patients should be treated in the PDQ process; we used Emergency Severity Index (ESI) as a surrogate. ESI is a 5-level classification system which categorizes patients by acuity and resource needs (Eitel et al. 2003). ESI levels 3 to 5 represent low risk patients who need many, one, or no resources, respectively, for their treatment. (In the ESI system, resources are procedures or tests that require staff outside the ED or considerable ED staff time.) Our model assumes that the PDQ provider will treat all ESI level 4 and 5 patients, and initiate diagnostics for ESI level 3 patients if no ED rooms are available.

We approximated teamwork activities in PDQ by making a list of major tasks and assigning them to individual team members, to sets of team members working jointly, or to sets of team members who were interchangeable for the particular task. We then assigned task priorities for each team member's tasks. Arena's resource sets and user defined priorities on individual resource requests were useful in implementing the approach. Another aspect of teamwork is that some of the staff will occasionally assist their cohort in the main ED; for example, in some trauma cases extra nursing staff are needed, and the PDQ provider has responsibility for some patients sent to the main ED. We modeled these activities by generating random requests for external support, and including these requests on the relevant task lists.

The PDQ provider has the largest number of tasks; several of these are of high priority and require interacting with other team members. For some of these tasks, we used resource preemption to interrupt lower priority tasks and reassign the PDQ provider to the higher priority task. Our reasoning was that some lower priority tasks had relatively long estimated times; in these cases the provider might choose to partially complete a task and return to it at a later time. Output analysis showed that resource preemption caused a substantial increase in the variance of patient length of stay, as compared to using the simpler priority approach. We therefore eliminated preemption from the model. In practice, the PDQ provider could use a combination of both approaches based on his or her best judgment and estimate of the remaining duration of a lower priority task, and different providers could use different approaches.

3.2 Modeling External Operations

Our focus is the PDQ process, but the model necessarily includes external activities and influences. Firstly, X-rays and complex laboratory tests require the use of hospital-wide laboratory facilities (some limited lab testing can be accomplished in the ED). Secondly, many arriving patients will need to be treated in the main ED, but the PDQ provider may initiate diagnostics for some of these patients depending on ED status. These patients will remain in the PDQ area until clinical space is available in the main ED.

Patients undergo randomly generated diagnostics based on estimates of the proportions of each category of tests required. If a test requires external resources, we model it as a time delay, sampled from a uniform distribution based on expert estimates. We do not attempt to capture activities of the external resources, but do model transportation requiring an EDT as escort.

The ED we are studying experiences frequent boarding (this term refers to patients who have been admitted to the hospital and who are waiting in the ED until an inpatient bed is available). Boarders reduce the capacity of the ED to treat incoming patients. Typically, the number of boarders increases throughout the day, then decreases overnight as patients are moved to hospital inpatient units. Boarding is widely recognized as a significant contributor to ED census and patient length of stay (Asplin et al.

2003, Cowan and Trzeciak 2005). Because of the influence of boarding, it is not correct to model ED capacity as a function of the patient arrival stream, and it is not practical to model inpatient unit capacity. We addressed this problem by including the probability of clinical space being available; this probability varies by hour of day, and is used in the model to determine if a patient needing complex diagnostics is immediately sent to the main ED.

4 RESULTS

Figure 2 shows average patient length of stay (LOS) by hour of day for 30 runs of the PDQ model. In this case, the system starts empty at 9 am and runs until 10 pm. This data includes only those patients who were discharged from PDQ (i.e., they did not require treatment in the main ED). The data is classified based on the patient's arrival hour; thus LOS for a patient who arrived at 9:45 am and left at 10:30 is recorded in the 9 am statistic.

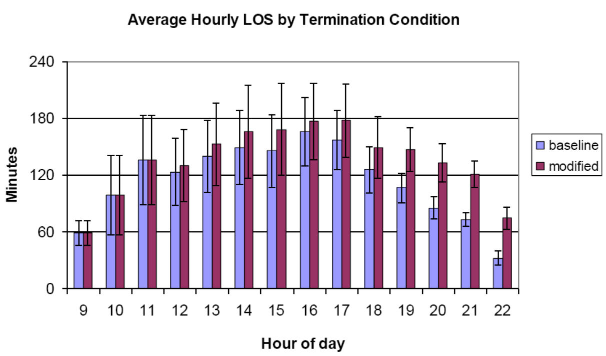

Figure 2: Average length of stay for 30 simulation runs

Patient average LOS climbs steadily through the day and begins to decrease in the evening, so reporting a daily average can be misleading. (This result is not unexpected, as the hourly arrival rate of patients shows a similar pattern.) The 95% confidence intervals shown in the figure are quite large during much of the day, as a result of large variability in interarrival times and a relatively small population of arrivals. The figure also demonstrates the effect of termination condition on the results. Implementation plans for end of day were to transfer patients whose remaining care was lengthy to the main ED. Initially, we shut the model off at end of day and did not collect statistics on patients remaining in the system. The result can be seen in the baseline data of Figure 2, which shows a sharp dropoff in LOS during the evening hours. We modified the model to run until all in-process patients were treated; these results are also shown in the figure. Still, this does not accurately reflect LOS late in the day as the main ED is not modeled.

Because of the problems with hourly LOS, we focused our attention on average hourly census, shown in Figure 3. Census increases over much of the day, but begins to decline in late evening. The 95% confidence interval half width also shows an increasing trend, again due to the high variability in the system.

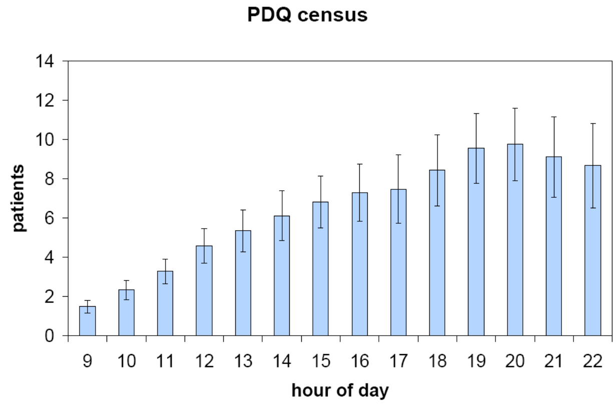

Figure 3: Average hourly census over 30 simulation runs

5 PILOT STUDY

The Hershey Medical Center ED implemented a pilot study of PDQ for approximately 1 month, and compared results to a baseline month in the previous calendar year. For both periods, staffing levels, patient arrivals, and patient acuity levels were similar. Table 1 compares the traditional approach to PDQ; results are tabulated for all patients presenting to the ED. The pilot study demonstrated substantial improvements for all patients; the effect is not limited to the low acuity patients who are treated by the PDQ physician.

Table 1: PDQ Year-to-Year Results Comparison.

Measure	Baseline	With PDQ	Improvement
LWBS	5.6%	2.7%	52%
Length of Stay	8 hr 6 m	6 hr 16 m	23%
Door to Room	71 min	45 min	37%
Door to Doctor	93 in	60 min	35%
ESI 4 LOS	5 hr 34 m	3 hr 9 m	44%
ESI 5 LOS	5 hr 51 m	1 hr 23 m	76%

To compare the simulation model results to the pilot study results, we made 30 replications and calculated 95% confidence intervals on mean LOS for ESI 4 and ESI 5 patients; the intervals were (2 hr 9 m, 3 hr 27m) and (1 hr 26 m, 2 hr 4 m), respectively. The average LOS for ESI 4 patients in the pilot falls within the confidence interval, but for ESI 5 patients the model overestimates average LOS. There are two issues that make validation difficult. Firstly, the confidence intervals are rather wide, primarily due to arrival variability. In addition, the pilot study results were collected over the entire 24 hour day; our model represents only the14 hours during which PDQ is in operation.

6 CONCLUSIONS

Provider directed queueing (PDQ) shows promise as a method for improving Emergency Department operations. The PDQ simulation model produced performance estimates similar to those obtained from a pilot study. The model allows a more detailed view of system performance under varying load.

A major benefit of simulation is the ability to predict the performance of alternative system designs. Hershey Medical Center is currently undertaking a large facilities project which will result in the addition of 7,500 square feet to the existing 25,000 square foot ED. The new space, and some renovated existing space, is being designed to facilitate the PDQ process. The simulation model and an associated animation are being used in the planning process for the new facility.

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