ABSTRACT
A Pre-Admission Testing Center (PATC) is a hospital unit that serves pre-operative patients. The role of PATC is to gather important patient information and perform procedure-specific tests to get the patients ready for surgery in the Operating Room (OR) on the surgery date. This “one-stop shop” approach to patient service saves a lot of time for patients. Patients can either walk-in to PATC or schedule an appointment in advance. In this paper, we explain the operations of a PATC and efforts to reduce patient waiting time. We analyze the system using a simulation model.

KEYWORDS: Pre-admission test, Pre-operative assessment clinic, Process improvement, Simulation model.

INTRODUCTION
Pre-admissions testing centers (PATC) is a crucial part of the surgery process for patients undergoing both inpatient and ambulatory procedures. PATC were developed in the 1980s and were set up to improve pre-operative assessment, reduce elective surgical waiting times and cancelled surgeries, and promote patient-centered care. PATC allows the patient to receive all auxiliary services in one place rather than running around in an outpatient testing area. PATC’s role is to allow hospitals to gather important patient information such as vital signs, perform procedure-specific tests ordered by the physician performing the surgery, assessing the patient’s readiness for surgery, and begin the chart preparation process so the Operating Room (OR) is ready on the patient’s surgery date. Furthermore, PAT fulfills the role of preparing the patient mentally for surgery by answering their questions about what to expect in the OR, especially regarding anesthesia.

The hospital network under study performs nearly 17,000 surgeries per year. Patients visiting PATC will see anywhere between two and five specialists depending on the patients’ need and their surgeons’ request. Each patient will speak with a pharmacist about their allergies and medications they are taking. Other procedures include drawing blood, X-rays, an EKG, speaking with a registered nurse about their medical history and what to expect on their surgery date, and meeting with a nurse practitioner about undergoing anesthesia. Although there are many
potential patient combinations, based on patient data a common patient requires all of the procedures mentioned above.

Recently, the PATC has been experiencing long wait times causing patient dissatisfaction and leading to delays in the Operating Room. While the network utilizes three hospitals to handle its immense surgery load, surgeons operating out of each of those hospitals all send patients to the same PATC. In this paper, we briefly explain the problem, develop a simulation model to predict patient wait time, find drivers of patient delay, conduct what if analysis and suggest options to reduce patient wait.

PROBLEM DESCRIPTION

Figure 1 describes the steps a typical patient has to go through before being admitted to OR. There are five exam rooms, one X-ray room, one EKG machine, five nurses, one pharmacist, one nurse practitioner, two lab technicians, and two X-ray technicians. Lab technicians and X-ray technicians, in addition to drawing blood and taking X-rays respectively, are cross-trained to perform EKG as well. For a given patient, the required tests are performed as resources/servers are made available, without any specific sequence or order. The management felt that one of the primary reasons for the patient delays is the lack of available resources, which can refer to either human or non-human resources. Human resources include five different types of servers (nurses and technicians), each with a unique skillset used to serve patients. Non-human resources include the exam rooms and medical equipment. There are five exam rooms, and each patient will be placed in an exam room during their visit. There is only one EKG machine at the PATC, and at times it’s used in other offices in the building. 53.4% of all patients require an EKG test. In addition, there is one X-ray room and part of the process for each X-Ray tech is to retrieve the patient from their exam room and bring them to the X-ray room. This means that only one X-ray process can be performed at any given time, and any patient that needs an X-ray may need to wait for the room to be available.

PATC accepts both scheduled and walk-in patients. Walk-in patients exacerbate the problem due to the resulting unpredictability of patient arrivals. PAT appointments are booked through the hospital network’s central scheduling department. There are thirty 20-minute PAT appointments available each day beginning at 7:00 AM. The arrival of walk-in patients is inherently unpredictable, and when walk-ins arrive at the same time as scheduled patients, patient wait times increase. Walk-in patients tend to get lower priority when PATC employees have to choose between two or more patients to serve, however their average wait time isn’t dramatically different from that of scheduled patients because their presence causes delays for both patient types throughout the system.

Some of the basic questions raised by the management are the following: a) How do we reduce patient waiting in PATC? b) Should we extend the working hours and keep PATC open on Saturday mornings to increase capacity? c) Do we have enough resources, both human and non-human to provide adequate service? If not what resource should we invest in? In order to answer these questions, we collected data for six week period to understand the patient arrival rates, inter-arrival times, the service times, the patient wait times in queue and the system. We analyzed the data and obtained many insights. These findings are used to recommend the required policy changes to the management. The details of the data analysis are reported elsewhere. A brief literature review is presented in the next section. In the following section, we describe the simulation model developed to answer the capacity related questions.
Figure 1: Flow chart showing a typical patient flow in PATC.

Provider Office schedules an appointment

Patient arrives at PAT on appointment Day

Patient gets Registered at PAT Front Desk

Patient waiting in Waiting Room

Pharmacy Tech checks Patient for Med Recon

Nurse takes Patient in the available Exam Room

EKG / Lab Technician / Nurse / Nurse Practitioner comes to Patient for services

X-Ray Tech takes Patient to X-Ray Room for services

Patient discharged to Home/Other discharge dispositions
LITERATURE REVIEW

There are many papers in the literature that explain the use of PATC in hospitals. Most of these papers describe how to use soft tools to improve efficiency in PATC. Pierro (1987) describes the implementation of a formal pre-admission testing program for elective surgical patients in a hospital. The author describes process of designing the program, marketing it to medical and hospital staff, implementing the program, and evaluating the effect of the program. Gilmartin et al. (2009) describe soft tools and methods for developing and improving pre-admission clinics for day surgery. Emanuel & Macpherson (2013) carried out a retrospective cross-sectional descriptive study to show that the anesthetic pre-admission clinic is effective in minimizing surgical cancellation rates. GE is one of the major companies to create improvement process tools to improve service in PATC. They used a value stream mapping, performed a rapid-cycle process improvement event to streamline a PATC (GE White paper, 2010). Creasy & Ramey (2013) use a six-sigma process to streamline a PAT process in a hospital. Kuhl (2012) considers patient flow and perioperative processes involved in day of surgery admissions for a hospital that is undergoing a staged redesign of its operating room. He develops a simulation model to map the patient flows and functions of the current area into the newly designed space, to measure potential changes in productivity, and to determine opportunities for future improvements.

THE SIMULATION MODEL

The simulation model is constructed using ARENA©, a simulation package developed by Rockwell Software, Inc. Before any insights from the model are derived, we explain the simulation methodology utilized, determine the appropriate number of replications and run length, and validate and verify the simulation model.

Simulation can be of two types- ‘terminating’ and ‘non-terminating’ or ‘steady state’ simulations. Terminating simulations are used to study existing systems and have a specific ending condition/event (Kelton & Law, 2000). A terminating simulation experiment will have multiple replications. Steady state simulations are used to study new systems or when altering an existing system (Kelton & Law, 2000). The focus here is on long-term measures of performance; there is no specific ending condition/event.

We developed a terminating type of system that mimics the operations of PATC. We assumed the system is open between 7:00AM and 5:00PM. The patient arrival rate is assumed be the same throughout the day. We assume that no more patients are accepted after 5:00PM, but service will continue until all patients who arrived before 5:00PM are complete. We assumed that the system clears at the end of the day and starts new the following day. We used the actual shifts used for nurses and techs in PATC as shown in Figure 2. Since customer waiting is significant during the peak period, we simulated the system during peak period only. The actual patient arrival rate is given in Figure 3. As we can see, the demand varies between 4 and 5.6 patients per hour during the peak period. Hence, we evaluate the impact of varying arrival rates on the patient waiting time. We assumed two types of patients, scheduled and walk-in. Given the arrival rate for scheduled, we assume that arrivals happen at equal intervals. The inter-arrival times are observed to follow exponential distribution. We fit distributions to all service times with the data that was collected. We ran the system for 500 days.
Validation is the process of determining if the simulation model is an authentic replica of the real-world or theoretical system being studied. If a model is a 'valid' representation of an actual/conceptual system, then its behavior would be consistent with that of the system under similar conditions (Kelton & Law, 2000). However, it is to be appreciated that a simulation model
is ultimately an approximation of the actual system for purposes of review and analysis. The models constructed for this research were carefully reviewed (with respect to the assumptions made) in order to ensure that they were ‘valid’ representations of the system being modeled. Verification refers to the process of ensuring that the assumptions of the conceptual model have been correctly converted into a computer program. It involves debugging of the program (Kelton & Law, 2000). In order to validate the results, we used two different methods. We first compared the results with the observed performance measures of interest. Because of the complexity of the model, we cannot build and solve an exact queueing model. We built an approximate queueing model and compared the simulation results with results from the approximate queueing model. We found that our simulation results are comparable to the results obtained from these two methods. We next present some initial results obtained from simulation.

ANALYSIS AND RESULTS

Since the management is keen on improving patient satisfaction and reducing patient wait time before they get to service, we choose the mean wait in queue as our primary performance measure. Figure 4 shows the impact of varying the hourly arrival rate on the mean wait time in queue. As we can see, for the current system with five exam rooms, the mean the mean wait in queue varies between 11 minutes and 26 minutes. Figure 5 compares the probability distribution of waiting time in queue corresponding to hourly patient arrival rate of 4 and 5.6 respectively. This explains how the distribution of wait time in queue is sensitive to the patient arrival rate. From the simulation, we also obtained the resource utilization for all the resources used in PATC and is given in Figure 6. As we can see, the resource with maximum utilization is the exam room with 84% utilization, and seems to be the bottleneck. The next bottleneck is nursing staff with a utilization of 71%. Currently, there are 4 full time nurses and one part time nurse working only for two and a half hours a day. We ran the simulation making the fifth nurse a full time nurse working between 7:30AM and 4:00PM, and adding one more exam room. Figure 4 compares the mean wait in queue with 5 exam rooms and 6 exam rooms with a full time fifth nurse. As we can see, during the peak period, the reduction in mean wait in queue due to this change is almost 50%.
Figure 4: Mean wait in queue (in minutes) as hourly patient arrival rate varies between 4 and 5.6.

Figure 5: Probability distribution of queueing time for hourly patient arrival rate of 4 and 5.6.
One of the concerns of the management was that should they buy one more EKG machine. Since the EKG machine is utilized only for 26% of the time, it does not seem to be the bottleneck.

As we can see from the above analysis, many of the concerns could be addressed using the simulation model developed in this paper. The full analysis and recommendation to the management will be reported elsewhere.

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REFERENCES


