Abstract

Health care organizations are beginning to use analytics to improve their quality of care. Objective of this paper is to provide a case study of using analytics to improve a healthcare process. We focus on providing a big picture of the project rather than presenting details of our data analysis and models used. We explain the operations of a Pre-Admission Testing Clinic (PATC) in a hospital and efforts to improve patient service by using analytics. A PATC gathers important patient information and performs all procedure-specific tests to get the patients ready for surgery in the Operating Room (OR) on surgery date. Patients are either scheduled an appointment in advance or allowed to walk-in to receive service in the PATC. Recently, the management has observed increased patient wait. Through data collection and analysis, we provided many valuable insights to the management on causes of the problem and suggested cost effective strategies to improve patient service.

1. Introduction

The health care industry is undergoing a significant transformation and health care organizations are beginning to use analytics to improve their quality of care. Objective of this paper is to explain a case study of using analytics to improve a healthcare process. The problem is complex and lends itself to develop new analytical models to get insights that are generalizable. However, our focus in this paper is to provide a big picture of the project and show that simple data analysis can reveal opportunities for improvement.

Pre-admissions testing clinic (PATC) is a crucial part of the surgery process for patients undergoing both inpatient and ambulatory procedures. Ambulatory surgery (also known as outpatient surgery, same-day surgery or day surgery) is surgery that does not require an overnight hospital stay. Patients today often don’t need to stay overnight because of improvements in pain medication and anesthesia, which allow patients to recover more quickly with fewer complications. Advances in medical technology allow doctors to use less invasive procedures than were once needed. This in turn reduces the complexity of the surgery, time needed to perform the surgery, complications resulting from a surgery, hospital re-admissions, and patient time, cost and stress. According to a report released from the National Center for Health Statistics at the Centers for Disease Control and Prevention, outpatient surgeries make up two-thirds of all surgeries [1]. Insurance changes also are pushing hospitals and doctors to perform more outpatient surgeries.

Before a surgery, a patient should be tested and prepared to make sure that patient can go through the surgery process successfully. Typical activities that need to be completed before surgery to prepare the patient are gathering patient information on patient biographical data, current medication, patient baseline observations (blood pressure, urine analysis, temperature, pulse etc.), previous anesthetics, allergies, medical history, and social history. Depending on the types of surgery, tests such as EKG and X-rays may also be needed. Before the advent of PATCs, test centers are organized as job shops to increase the economy of scale. Patients need to schedule and attend multiple appointments at multiple test centers that are spread throughout the hospital or even sites outside the hospital. This increases total time needed to complete all the tests, increases cost of patient disruption. The tests may have to be performed in a non-optimal sequence. Multiple test administrators do not communicate with each other and hence the quality of the overall assessment is reduced. If the tests are not completed on time and the test results are not available the day before surgery, the surgery may have to be cancelled.

An alternative to the above patient preparation process is to admit surgery patients to hospital at least a day before surgery to complete all the pre-operative patient preparation. However, if they find that patients are not ready for the surgery, they have to cancel the surgery. PATC were developed in the 1980s and were set up as “manufacturing cells” so that it is a one-stop-shop for patients. The objective is to improve pre-operative assessment, reduce elective
surgical waiting times and cancelled surgeries, and promotes 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, PATC fulfills the role of preparing the patient mentally for surgery by answering their questions about what to expect in the OR, especially regarding anesthesia. PATC helps to streamline processes, improve procedures and standardize documentation. PATC help integrate disciplines such as anesthetists, physiotherapists, occupational therapists, pharmacists and advanced nurse practitioners into the overall team. Pre-admissions testing is a crucial component to ensuring that patients are appropriately selected, informed and prepared [2]. Note that staff in a PATC is multi-skilled and cross trained. In order to balance the cost of increased staff and multi-skilled workers, there should be enough patient demand for service. There is also increased cost of equipment because you will be performing multiple tests in one clinic.

In this paper, we report the study we conducted to improve patient service in a PATC. In the next section, we briefly explain the problem, data collection and analysis, and insights obtained from the from data analysis that lead to our recommendation on possible improvement strategies.

2. Problem description

All The structure and function of a specific PATC could vary significantly. The hospital network under study performs nearly 17,000 surgeries per year. 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. Patient selection for surgery usually begins at outpatient clinics, by medical staff referring potential patients to the day surgical unit for pre-admission assessment (Fig 1 and 2). Patients visiting PATC will see anywhere between two and five specialists depending on the patient’s need and their surgeon’s 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.

Figure 2 describes the steps a typical patient has to go through before being admitted to OR. There are total of 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. PATC uses multiple resources, both human and 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 is used in other offices in the building. 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. Surgeons’ offices either ask patients to walk-in to PATC or book PATC appointments through the hospital network’s central scheduling department for patients. There are thirty 20-minute PAT appointments available each day beginning at 7:00 AM until 5PM. 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.

Recently, the PATC has been experiencing long wait times causing patient dissatisfaction and leading to delays in the Operating Room. The management felt that one of the primary reasons for the patient delays is the lack of available resources. The management wanted to improve patient satisfaction
and raised the following basic questions. 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 developed a questionnaire and collected data. We analyzed the data, developed an approximate queuing model, and an exact simulation model. The results of these models are presented elsewhere. However, the many insights obtained from the study and our recommendations to the management are reported in section 4. A brief literature review is presented in the next section.

![Figure 1: Flow chart showing a typical patient flow from primary care provider visit till the completion of surgery.](image)

![Figure 2: Flow chart showing a typical patient flow within the PATC.](image)

### 3. Literature review

There are many papers in the literature that explain the use of PATC in hospitals. Most of these papers describe how to improve efficiency in PATC. Pierro [3] 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. PATC could improve the efficiency of elective surgical admissions [4]. Gilmartin et. al [5] describe tools and methods for developing and improving pre-admission clinics for day surgery. 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 [6]. Creasy and Ramey [7] use a six-sigma process to streamline a PATC process in a hospital. Kuhl [8] 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. There are several studies in the literature investigating the reasons for cancellation of scheduled surgeries [9]. Late cancellations result in inefficient use of OR time and wastes resources. It is potentially stressful and costly to patients as well. PATC reduces late cancellations of scheduled surgery. Emanuel and Macpherson [10] carried out a retrospective cross-sectional descriptive study to show that the anesthetic pre-admission clinic is effective in minimizing surgical cancellation rates. Several studies investigate patient perception of their preparation for surgery in PATC. They show that PATC relieve patients’ anxiety [11, 12, and 13].

4. Analysis and results

We developed a questionnaire and gave it to the nursing staff. We collected data on patient category, the physician recommending the surgery, surgery date, required tests to be performed, whether patients are scheduled or walk-in, the time of their arrival, and start and end times for each test. The duration of the data collection period was nine weeks (a total of 46 working days). Overall, there were 1,480 patients arriving during this period. The details of patient category are shown in Figure 3. As we can see, majority of the patients need all tests.

In order to understand the patient arrival rates, we averaged the daily patient arrivals by hour and the results are shown in Figure 4. As we can see, the peak periods are between 9:30AM and 12:30PM with arrival rates varying from 4 to 5.5. More than 40 percent of the patients are walk-in patients. Interestingly, on an average, there are more walk-ins during the peak period between 9:30AM and 12:30PM.

As we know from the queuing theory, variation in the arrivals and service times robs the capacity and increases patient wait. To study the variations in patient arrivals, we fitted inter-arrival time distribution. For example, inter-arrival time distribution for walk-in patients is given in Figure 5. We found that for both scheduled and walk-in patients, the inter-arrival times follow and exponential distribution. This suggests that inter-arrival times of all patients including scheduled patients are completely random. Even the scheduled patients do not arrive at the scheduled time. In addition, we also found that there is significant variation in some test times. Although we have less control in reducing the variation in test times, we decided to explore further the reasons for variation in the patient arrivals.

![Figure 3: Graph showing patient categories](image)

![Figure 4: Patient arrival rate per hour for scheduled and walk-in patients for a typical day.](image)

![Figure 5: Inter-arrival time distribution for walk-in patients](image)
We analyzed walk-in patient data by surgeon names and found that some surgeons send more patients as walk-ins than others as can be seen from Figure 6. Discussion with doctors’ office revealed that, irrespective of time till the surgery date, some doctors want to send patients who come from long distance as walk-ins the same day they see them in their office to avoid another trip and reduce their cost and time. Figure 7 shows the percent of patients with time till surgery is 7 or more days. As we can see, more than 55% of the walk-ins have at least seven days till the scheduled surgery date. Doctors are not aware of the implications of sending a patient as a walk-in. It seems that there are no guidelines for doctors to decide whether to schedule a patient or send a patient as walk-in. One option is to come up with some guideline such as sending a patient as walk-in only if the surgery is scheduled within the next seven days and communicating it to the doctors.

There are thirty 20-minute PAT appointments available each day beginning at 7:00 AM until 5PM. We analyzed the actual patient appointments given and graphed the results in Figure 8. As can be seen from the graph, there are more appointments given at 7:40AM, 8:40AM, 9:40AM, and 10:40AM. Since many of these time slots are in the peak demand period, we asked the management the reason behind this. We found out that they are not aware of peak demand period and when PATC was initially formed, the schedulers were allowed to double book only during these four time slots. Schedulers continue this practice without realizing that they are double booking during the peak periods! We recommended that they stop this practice.

As mentioned earlier, the inter-arrival time of scheduled patients is exponentially distributed showing the scheduled patients do not arrive on time. We calculated the difference between the scheduled and actual arrival times of these patients. More than 50% of the patients arrived at least an hour early or late for a scheduled appointment. As can be seen from Figure 9, many of these late or early arrivals
happened during the peak time of the day. After discussing with the schedulers, we found that schedulers are more interested in getting patients registered and scheduled. In order to do so they inform the patients that scheduled time does not matter and they can show up any time that day. We recommended that the management inform the schedulers to communicate the importance of on-time arrival to the patient.

Figure 9: Number of patients arriving at least an hour early or late for a scheduled appointment.

5. Summary and Recommendations

In the previous section, we presented some of the analyses we have conducted. We also developed an exact simulation model to answer many what if questions related to capacity utilization. The results are presented in [14]. Based on our overall analyses, some of our recommendations to the management included the following.

1. It is important to reduce the walk-in arrivals. The management could come up with some guideline such as sending a patient as walk-in only if the surgery is scheduled within the next seven days and communicating it to the doctors.

2. Reduce variation in inter-arrival times of scheduled patients by encouraging the scheduled patients to come on time for appointments.

3. Attempt to spread the peak period – Keep the total arrival rates to less than 4 per hour. This can be done by extending the week day hours or opening Saturday morning hours. Note that in spite of extended hours may not alter the current demand during peak periods (with arrival rate of more than 4 patients per hour)! If this happens, extending hours is not beneficial.

4. Based on our queuing and simulation analysis, the bottleneck resources during the peak period are exam rooms and nurses, but not EKG or X-ray room. Hence, if the above changes do not reduce the patient delay, management may explore the possibility of adding one more exam room.

The management is in the process of implementing the above recommendations.

In this paper we explained a case study of using analytics to improve a healthcare process. The problem is complex and lends itself to develop new analytical models to get insights that are generalizable. However, our focus in this paper is to present a big picture of the project and show that simple data analysis can reveal gaps in communications and provide opportunities for improvement. Although academics may concentrate on developing complex models with simplifying assumptions and seek for generalizable results, we believe the first step in practice should be to use simple data analysis to understand the gaps in the system and make improvements in the overall process. We also note that it is not yet a common practice to use analytics to make decisions in healthcare organizations.

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7. References


