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Optimization of the Operation Suite Scheduling Process at a Rural Hospital

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Abstract: There are multiple ways to determine the productivity of a hospital, its staff, and its operating rooms. One specific hospital, Chenango Memorial Hospital (CMH), is having problems with utilization. To increase their utilization, the Binghamton University student team focused on surgeon utilization, operating room utilizations, and the percentages of surgeries that are scheduled outside of their designated block. The team employed the bin packing algorithm to develop a scheduling method, maximizing OR suite utilization at the hospital. The team recommended scheduling more surgeries within surgeons' blocks and switching to a half block schedule to maximize total hospital resources such as nurses and anesthesiologists.

Keywords: Utilization, Process Mapping, Data Analysis, Bin Packing Algorithm

1. Introduction

Chenango Memorial Hospital (CMH), a United Health Services hospital servicing the town of Norwich, New York, and neighboring towns such as Sidney, Sherburne, and Oxford, has identified that the underutilization of the operating room suite is a central problem to business operations. As such, Binghamton University (BU) students were brought in to investigate and provide recommendations for how to fix the system.

The hospital has 138 total beds, with 58 used for hospital patients and 80 for the nursing home facility located on the 2nd floor of the facility (UHS). The hospital's operating room suite (OR) is open from 7 A.M. to 5 P.M., Monday through Thursday, for a total of 40 operational hours per week. The OR suite has five rooms. Four rooms are specialized based on the material and equipment stocked in those rooms and the fifth room is reserved for emergency surgeries. There are 12 total surgeons who work for the client with surgery types including OBGYN, ophthalmology, orthopedics, podiatry, neurological, gastrointestinal, pain management, general, and vascular surgery. Surgeries are scheduled using a block schedule which is developed internally by the hospital staff. The block schedule gives each surgeon specific 8-hour blocks during the week in which they can schedule surgeries.

2. Data

The client provided the BU team with two sets of data and two block schedules. The first set of data and block schedule covered data from January 1st, 2023 to October 12th, 2023. The second set of data and block schedule covered data from November 1st, 2023 to February 13th, 2024. Each of these data sets include all surgeries conducted during the specified time frame and the details of each surgery. In total, there were 1,437 surgeries in the first set of data and 577 surgeries in the second set. Each surgery included information such as date, classification, surgeon, in-facility time, surgery start time, and surgery end times among other metrics. Please note that surgeon and patient confidentiality was protected by the client as all data provided to the BU team was coded. Surgeons were coded with letters unrelated to their given names, for example "Surgeon X," and any data which could be linked to a specific patient was removed from the data set.

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3. Methodology

The team started by first developing a process flow of the surgery process at the client hospital. The team members worked closely with the head ambulatory and OR nurses to understand the full process, starting with patient referral and ending when a patient exits the hospital. Team members verified the validity of the process through various in-person meetings with the head ambulatory and OR nurses as well as online meetings with the team's advisor. The team broke the process down into steps with 15 value-added events (green), 11 business value-added events (yellow), and 6 non-value-added events (red), as can be seen in Figure 1. An example of a value-added event is when the preadmissions testing nurse calls the patient to schedule the preadmissions testing appointment. An example of a business value-added event is taking the time to enter a case in Epic, the scheduling software employed by the client. An example of a non-value-added event is the rescheduling of a surgery if a problem is found during the preadmission testing appointment. The non-value-added events were then selected as areas of interest for the BU team to further analyze.

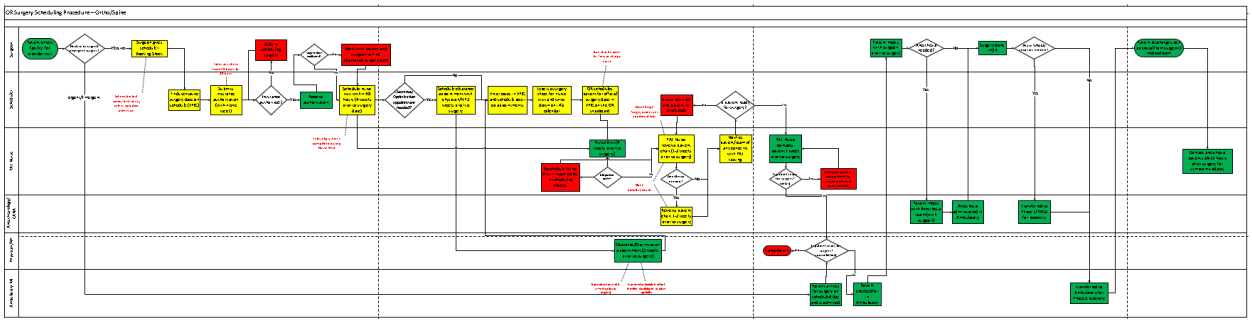

Figure 1. Process Flow for the Client's OR Suite

In parallel to the process flow development, the team also completed data analysis on the data provided by the client. One particularly useful metric calculated was the utilization of OR rooms, surgeons, and anesthesiologists. Utilization was calculated by finding the total time a resource was in use and dividing by the total time the resource was scheduled to be used. For example, off block surgeon utilization was found by finding the total time a surgeon worked in the OR and dividing it by the total block time they had scheduled on the block schedule. On block surgeon utilization was calculated by finding the total time a surgeon worked in the OR on their block and dividing by the total block time they had scheduled. Other metrics calculated include the mean and median times surgeons leave daily, the average number of surgeries performed per day and by each surgeon, and the percentage of first procedures of the day that start on time. Studying the data analysis allowed the BU team to identify bottlenecks within the client's system, specifically within the context of resource utilization and allocation.

Following the completion of the data analysis phase the team developed a set of bin packing models. The bin packing algorithm aims to pack a list of items into the minimum number of bins of a fixed size (Munien, 2020). In doing so, the algorithm minimized the resources used to meet a fixed capacity and, with the inclusion of various constraints, meet the needs of a specified organization. In the client's case, the items are the surgeries being performed in the OR while the bins are the days of the week the OR is open for operations. The team was able to include constraints such as hours of operation, the hard cutoff for surgery start time at 4 P.M., and limits on the number of surgeries performed per day due to the number of nurses and anesthesiologists employed by the client.

The BU team developed one bin packing model of the current state of the client's OR suite and one model of an ideal state given the most recent block schedule. When used correctly, optimization models have been proven to increase the number of surgeries an OR suite can complete while lowering surgery delays and rejections (Bandi, 2018). The bin packing model was chosen because of its ability to take into account historical case count and length data, the block schedules provided to the BU team, the various constraints provided by the client, and the preferences of the client's surgeons (Bandi, 2020).

4. Results

The team was able to calculate surgeon utilization for both sets of block schedules. Utilization was calculated by finding the total time a surgeon worked in the OR suite and dividing by the total time the surgeon was allotted to work based on their assigned block schedule. It was found that while surgeon utilization was low for both block schedules, utilization was far lower than the client expected when taking into consideration surgeons working off block. Off block work was taken into account by subtracting the time surgeons worked off their block from the total time the surgeon worked in the OR suite. The

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time the surgeon worked within their assigned block schedule was then divided by the total time the surgeon was allotted to work based on their assigned block schedule. Figure 2 shows the differences between the client's surgeons working on block (blue) versus the total time they worked regardless of block (orange). Figure 2 was shown to the head ambulatory nurse and head OR nurse to gauge whether the team's findings were accurate to the experiences of the nurses. This was confirmed and the team homed in on surgeon utilization as a main area of OR underutilization.

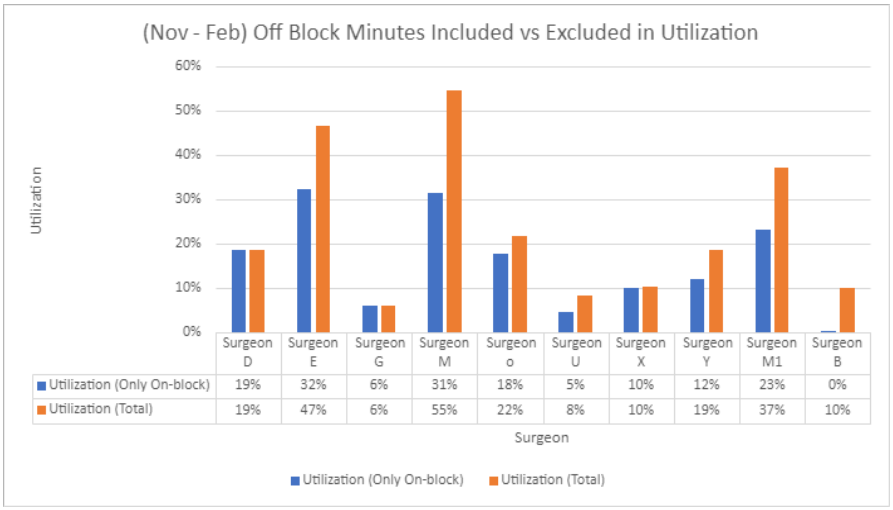

Figure 2: Surgeon On-Block vs Off-Block Utilization for Second Data Set

The team then calculated the mean, median, minimum, maximum, range, and the standard deviation of surgeon leave time from the OR. These calculations had to be approximated by the end time of each surgeons' last surgery per day they worked as data was not provided to the team about surgeon working hours. Figure 3 shows the median leaving time of the 12 surgeons currently working at the client hospital. The median leave time was chosen because it accounts for variation within surgeon leave time better than the mean leave time. Some surgeons were found to have large ranges in their leave time and outliers that could potentially lead to a skewed mean. The median and mean leave times were calculated and compared to one another before this selection was made. Figure 3 shows the OR being open from 7 A.M. until 4 P.M. when the latest procedure could start based on the constraints given by the client. The blue blocks represent the time a surgeon spends in the OR, with the end of the block showing the time the surgeon typically leaves by. Using this visual the team found that surgeons regularly left the OR before the end of their assigned block. Surgeons leaving early resulted in them underutilizing their scheduled time as well as other hospital resources such as scheduled nurses and anesthesiologists. The team determined that surgeon leave time was an issue regarding the overall OR underutilization.

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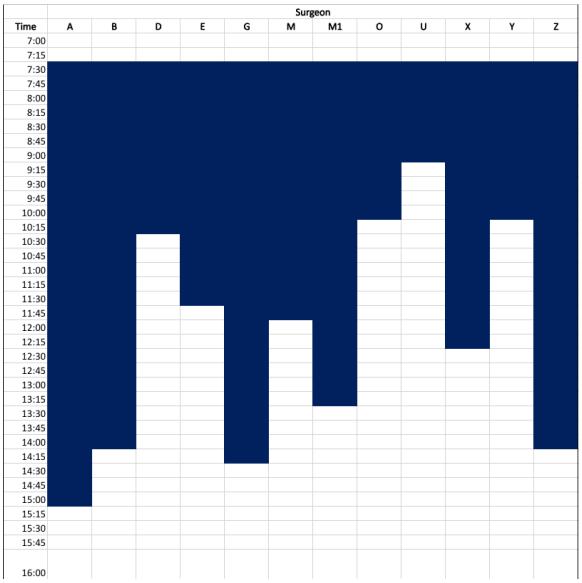

Figure 3: Median Surgeon Leave Time

The team also investigated resource utilization outside of surgeon utilization. As such, room utilization for both block schedules was calculated and presented to the client for verification. Room utilization was calculated by adding the total time a room was used by the client and dividing by the total time the room was open for business over the same period. The findings can be seen in Figure 4. Room utilization for the first set of data can be seen in blue (denoted old) while the utilization for the second set of data can be seen in orange (denoted new). Note that room 4 is the room that is reserved for emergent cases, accounting for low utilization. Based on the results found, room utilization was not found to be a limiting factor for the client's OR suite underutilization. The BU team then decided to focus improvement efforts on increasing surgeon utilization as opposed to other limiting resources in the client OR.

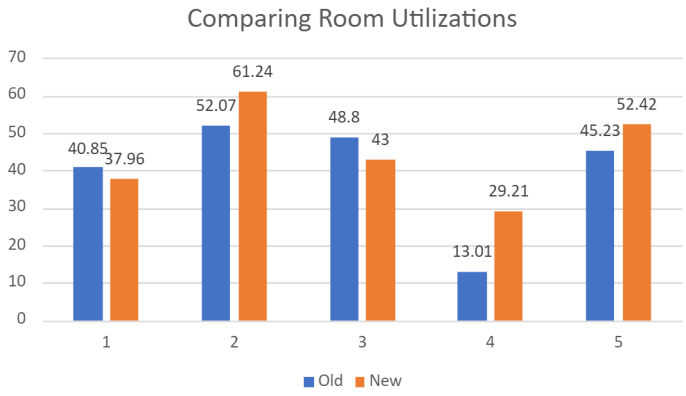

Figure 4: OR Suite Utilization by Room Number

Following the analysis of surgeon on block utilization, off block utilization, and leave times the BU team created an ideal and a current state bin packing model for the client's OR based on January operations. These models were then placed side by side in one model for comparison between the two scenarios. This side-by-side comparison can be seen in Figure 5 and shows four days the OR was open for business. Columns labeled in gray indicate the current state of the client OR and show the surgeries that took place each day by surgeon. The columns labeled in green represent the ideal state where the client OR is operating at maximum efficiency given the client's constraints. Figure 6 shows the color codes used within the bin packing model to show the different types of surgeries in scope and whether they were on or off block. Surgeon codes, surgeon number of cases, and the utilization of surgeon's blocks can be seen in the model. Each surgery consists of three blocks, the first being surgery setup time, the second being the surgery length, and the final being the surgery cleanup time. The model was shown to client staff to verify the validity of the model prior to conclusions and recommendations being made by the BU team.

Figure 5: Snapshot of the Combined Ideal and Current State Bin Packing Models

Legend	On-Block	Off-Block
Emergency		
Inpatient		
Hosptial Outpatient Surgery		
Outpatient in a Bed		
Surgery Admit		
Ideal State		

Figure 6: Legend for Colors Used within the Bin Packing Model

In parallel with the utilization research, the BU team sought to address one of the largest complaints the client received from patients: the operating process was confusing. Patients complained that there was no clear process for them to move through as they transitioned from pre-admission testing to the day of surgery. The patients did not know how many steps there were or what would happen next in the process. To address this, the BU team developed a patient process flow visualization, seen in Figure 7, based on the current state process map. This visualization is tailored for patients and allows them to see a timeline of what they can expect in the weeks leading up to surgery, thus increasing patient satisfaction with the client hospital.

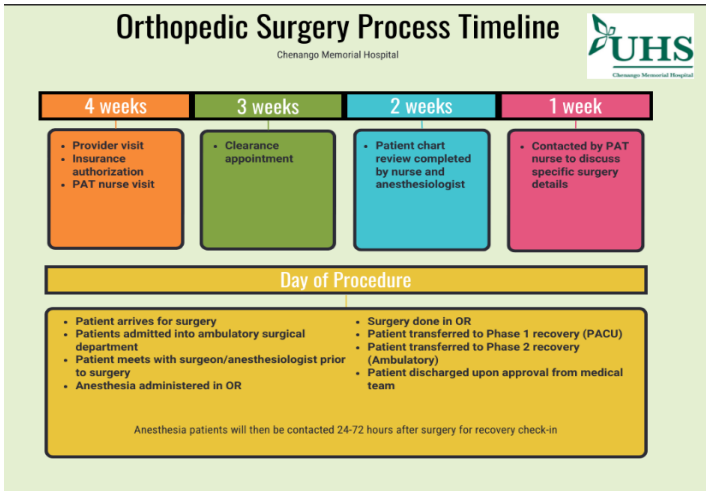

Figure 7: Process Flow Visualization for Patient Use

5. Conclusions and Future Work

Based on the client's findings the team has already had a major impact on the client from their findings. In early February, the team presented to the client and highlighted both the results from the data analysis and current process mapping. Through this, the team was able to highlight discrepancies in surgeon utilization, in relation to the block schedule. It was found that specific surgeons regularly went off their block schedule and caused scheduling difficulties for the rest of the OR in terms of resource allocation. Surgeons, nurses, anesthesiologists, rooms and other hospital resources were regularly underutilized, or mis utilized, due to surgeons working off block. By highlighting specific surgeons, the team was able to give the client's administrators actionable evidence to use in confronting these surgeons. Based on the team's findings, the client was able to readjust the block schedule to account for surgeons' actions.

The team was also able to use the combined current and ideal state bin packing models to show the client the underutilization of their surgeons. Surgeon underutilization was attributed to block underutilization, surgeons electing to work outside of their block hours, and surgeons leaving the client's facilities to fulfil other obligations they have as medical providers. As such the BU team recommended that the client schedule more surgeries within surgeon's blocks to increase their utilization. If the client were to follow the scheduling strategy the BU team suggested the client could increase overall surgeon utilization from 58.12% to 82.70% on average. An additional benefit of the scheduling strategy the BU team suggested would be a level loading of the client OR workload. In the current state, the client has days where OR utilization is over 100% as surgeries go far past the 4 P.M. cut off point. The BU scheduling strategy would limit the times certain types of surgeries could start, limiting the possibility of surgeries going past the 4 P.M. cut off point.

The BU team also suggested that the client should consider limiting surgeons who leave around 12 P.M. to a half block schedule. Implementing a half block shift would allow the current surgeons who work until around 12 P.M. to see their complete schedule of patients while freeing up valuable hospital resources later in the day. With this half block schedule implemented, the client could schedule a second provider during the second half of the usual 8-hour shift, maximizing the amount of time the OR is both open and functional. Not only would this benefit patients who may be waiting for surgeries to get scheduled, it would allow OR resources such as nurses and anesthesiologists to work their complete 8-hour shifts.

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