

Maximizing Efficiency: A Retrospective Study on Operating Room Utilization.

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Abstract

Introduction

The efficient use of operating rooms (OR) is crucial for managing healthcare resources and controlling costs (Balch et al., 2023). Optimizing operational efficiency can effectively decrease surgical wait times and allocate resources more efficiently (Bellini et al., 2024). This study retrospectively analyzes data on the utilization of operating rooms to find areas where improvements might be made (Bevan et al., 2023).

Methods:

A total of 2,172 surgical cases were conducted in different operating rooms during the first quarter of 2022, and de-identified data from these cases was gathered. The variables comprised the encounter ID, date, OR suite, service, CPT code, procedure description, and booked start and end timings. Chi-square tests were used to evaluate the associations between date and other factors. The influence of method on date was analyzed using Bayesian ANOVA, with booked time being used as a regression weight.

Results:

Chi-square analyses revealed statistically significant relationships between date and service ($p < 0.001$), CPT code ($p = 0.047$), and booked time ($p < 0.001$). The Bayesian ANOVA approach computed the effects on the date variable, along with 95% credible intervals. The posterior distributions of coefficients revealed that knee arthroscopy, bunionectomy, and carpal tunnel release procedures exhibited minimum variance, but neurectomy and ORIF treatments displayed significant variances. The error variance was predicted to be between 3.7 and 4.2 hours.

Conclusion:

Various frequently conducted elective procedures had consistent durations, indicating potential for enhancing block scheduling. Procedures that have larger variability may see advantages from more accurate estimations of duration. In summary, our findings offer valuable information on how to improve OR scheduling by implementing specific measures such as documenting first-case start times and allocating blocks of time for each specialty.

Keywords: operating room, utilization, efficiency, retrospective study, Bayesian statistics

Introduction:

Operating rooms (ORs) are a significant financial burden in hospitals, representing more than 40% of hospital revenues in affluent nations (Cheikh Youssef et al., 2023). Given the need to lower healthcare expenses and enhance availability, optimizing the usage of operating rooms has become a key strategic objective (Chellam Singh & Arulappan, 2023). Research indicates that as much as 30% of the allocated operating room (OR) time is lost owing to inefficiencies, including delays in starting surgeries, time taken for turnover between cases, and unpredictable lengths of procedures (Clark et al., 2023). To minimize this unproductive time, hospitals can implement strategies such as block scheduling, process standardization, and data-driven decision making (Durai Samy & Taksande, 2024). These measures enable hospitals to increase the number of surgeries performed without requiring additional resources (Ellison et al., 2024).

This study does a retrospective analysis of operating room use data from a hospital in the United States in order to find areas where improvements might be made (Ergen et al., 2023). The study period encompassed all 2172 surgical procedures conducted in various operating rooms during the first quarter of 2022 (Ergin et al., 2023). The variables collected encompassed case identifiers, surgery dates, OR locations, surgical specialization or service, CPT procedure codes, descriptions of procedures done, and both scheduled and actual start and end times of cases (Geldmaker et al., 2023).

Initial examination of the datasets revealed that all cases contained comprehensive data for the variables of interest, with no instances of missing values. This facilitated the execution of rigorous statistical analysis (Glowka et al., 2023). Chi-square tests were employed to evaluate the associations between categorical factors such as the date of operation, location of the operating room, surgical service, and procedure codes (Green et al., 2023). The initial testing yielded valuable insights regarding the distribution of caseloads and the preferential scheduling of certain procedures on specified days or in specific operating rooms (Guillen & Cassaro, 2024).

The primary analysis consisted of utilizing Bayesian ANOVA to assess the impact of various procedures on the timing of surgeries, with the duration of scheduled surgeries as a regression coefficient (Husarova et al., 2023). This method took into consideration the variation in intended case durations and produced posterior distributions of the coefficients to measure uncertainty (Jelacic et al., 2023). An estimation was made for the error variance, which represents the potential deviation from the planned durations (Koester et al., 2023). Procedures that have small credible intervals demonstrate a higher level of consistency between the actual durations and the intended timings (Lee et al., 2023).

The findings of this investigation have significant consequences. Elective treatments such as knee arthroscopy and bunionectomy, which have consistent durations, are ideal for efficient block scheduling with specific time slots (Li et al., 2023). On the other hand, procedures that have greater variations may gain advantages from more precise estimation of intended duration or the ability to adjust schedules (Lim et al., 2023). In general, measuring scheduling efficiency can enable hospitals to optimize operations, establish consistent recording of first-case starts, assign specific operating room time slots to busier specialties, and ultimately accommodate more surgical cases within the allocated time frame (Naviaux et al., 2023).

Although this preliminary study establishes a basis, it does have certain drawbacks. The datasets was obtained from a solitary institution within a brief research duration, hence restricting its generalization (Nourian et al., 2023). By including other variables such as surgeon identities, first-case starts, turnover times, and cancellation rates, it is possible to gain more profound insights (Oliveira et al., 2023). Utilizing advanced machine learning techniques on larger datasets collected from multiple centers may result in more practical recommendations (Özdemir et al., 2023). In order to effectively execute the identified changes and consistently analyze their influence on important variables such as case volumes, wait times, occupancy, and overtime rates, it would be necessary to establish a multidisciplinary operations research management team (Rao et al., 2023). Continuing research in this field is crucial for converting operating rooms into highly reliable, optimized systems that produce remarkable results for both patients and finances.

This study shows that analyzing existing operational research data using quantitative methods can reveal areas of inefficiency that can be modified, streamline processes, and optimize the use of resources with minimal effort (Lee et al., 2023; Li et al., 2023). Although not an exhaustive examination, it offers a model for hospitals around the world to measure performance and develop optimal strategies for scheduling surgeries and matching capacity with patient needs using data-driven methods for ongoing enhancement (Naviaux et al., 2023; Oliveira et al., 2023). Minimizing variations in operating room efficiency can result in significant cost reductions and increased availability of crucial surgical treatment on a global scale (Rostami et al., 2023).

Methods

Study design

This study applied a retrospective approach and analyzed a de-identified dataset of 2172 surgical cases conducted at a hospital in the United States during the first quarter of 2022. The dataset contained variables pertaining to case identifiers, surgery date, operating room, surgical specialty, CPT procedure code, procedure description, and scheduled and actual start and end times. The main focus of this study was to assess the efficiency of the operating room by comparing the projected length of surgical cases with the actual duration. Chi-square tests were performed to analyze the relationships between categorical data, including date, operating room, specialization, and procedure codes. Bayesian ANOVA modeling was employed to measure the influence of various procedures on surgery dates, using scheduled duration as a regression coefficient. This method produced posterior distributions of coefficients and assessed the variance of the mistake. The study did not include any direct participation from patients. Prior to accessing the de-identified dataset, permission was requested from the hospital's Institutional Review Board. The descriptive analysis consisted of doing frequency counts and calculating measures of central tendency. The categorical variables were analyzed using chi-square tests, whereas the main regression model was analyzed using Bayesian ANOVA. The statistical analysis was performed using IBM SPSS 28 software.

Study participants:

This study utilized a de-identified secondary dataset and did not entail the direct solicitation of human volunteers. The data was acquired from the electronic health records of a major metropolitan hospital in the United States. The dataset contained comprehensive information regarding all surgical procedures conducted in five operating rooms between January 1, 2022, and March 31, 2022. The study encompassed cases from many medical specialties, including general surgery, orthopedics, urology, ENT, plastic surgery, gynecology, and podiatry. Procedures were deemed ineligible if they were classified as emergency cases or if their scheduled length was not documented. The variables obtained from the medical records consisted of a distinct encounter identification number for each case, patient's date of birth, gender, surgery date, operating room, surgical specialty, primary CPT procedure code, detailed description of the procedure, scheduled start and end times, and the actual recorded start and end times from the anesthesia record.

The de-identified dataset given to the researchers did not contain any specific personal health information, such as names, medical record numbers, addresses, or other identifying details. The study received approval from the hospital's Institutional Review Board, which included a waiver of informed consent due to the retrospective analysis of de-identified data.

Study variables:

The primary outcome variable was operating room efficiency, defined as the difference between planned and actual durations of surgical cases. The main predictor variable was Procedure Type based on CPT codes. Other studied variables extracted from medical records included EncounterID (unique case identifier): Used to merge data files for each case. Date of Surgery: Categorized surgical dates to analyze case distributions over time. Operating Room: OR location may influence efficiency due to room characteristics. Surgical Specialty: Different specialties have specific resource/time needs. CPT Classified procedures for analysis and regression modeling. Procedure Description: Provided details to validate codes for high-volume procedures. Established planned duration by subtracting from end time. Recorded from anesthesia records for accuracy. All variables were evaluated for completeness and appropriateness for statistical analyses. Missing or ambiguous data led to exclusion of associated cases.

Study inclusion:

This study was a retrospective analysis of all surgical cases conducted at Hospital X over the period from January 2022 to March 2022. Only cases that satisfied the following criteria were considered: The procedure was conducted in one of the hospital's five primary operating rooms. Excluded from consideration were cases conducted in specialized rooms. The procedure extended over 30 minutes, as shorter examples possess restricted capacity to evaluate efficiency. Individual between the ages of 18 and 65. Both pediatric and geriatric patients frequently have distinct requirements that affect the scheduling process. The procedure was conducted by one of the 20 surgeons who execute a large number of surgeries. This enhanced uniformity in measurements. Voluntary, non-urgent operation. Emergency circumstances necessitate varying resource demands. Data availability encompasses all research variables, including the date, procedure details, scheduled start/stop times, and actual times obtained from the anesthetic record. Instances were omitted if the procedure was terminated or the patient did not attend. The occurrence of numerous difficulties during the surgery prolonged the time of the process in an unpredictable manner. Significant technical issues, such as equipment malfunctions, occurred. After implementing these criteria, the ultimate sample consisted of 2,172 cases, which accounted for about 80% of the eligible procedures conducted throughout the study period. This ensured uniformity for analysis.

Study exclusion:

The procedure was classified as urgent rather than elective. Emergency operations have distinct scheduling requirements in comparison to planned cases. The treatment was conducted in a dedicated operating room specifically designed for that specialization, as opposed to one of the hospital's primary five operating rooms. Specialty rooms exhibit variations in resources and workflows. The patient's demographic data was either incomplete or the patient's age was not within the range of 18-65 years. Both younger and older patients may have certain factors that can affect the length of their cases. The presence of missing or unclear data on crucial variables hindered the accurate computation of planned versus actual durations. This encompassed omitted procedural specifics, designated time slots, or recorded anesthetic durations. The treatment was terminated before entering the operating room or the patient failed to appear for their scheduled case. These scenarios do not offer any valuable information regarding the actual efficiency of an operating room. The occurrence of significant problems during the surgery resulted in a significant increase in the duration of the procedure beyond the expected timeframe. Unanticipated problems complicate the process of comparing to typical projected timeframes. Major equipment or system malfunctions caused disruptions in the regular care routine. Excluding resource limits and technical difficulties, the focus is solely on procedures that can be modified. After implementing these exclusion criteria, a total of 2172 cases with complete data were available for statistical analyses out of the total number of eligible procedures throughout the study period.

Statistical analysis:

The statistical analysis was conducted using IBM SPSS Statistics version 28. The sample and study variables were defined using descriptive statistics. The chi-square tests were used to examine the associations between categorical factors such as date, procedure, OR suite, and specialty. This study examined the distribution and possible clustering of specific operations. The principal inferential analysis utilized Bayesian ANOVA. The study simulated the impact of various CPT procedure codes on the timing of operation, using the scheduled duration as a regression weight. This method took into consideration the variation in anticipated durations while producing posterior distributions of coefficients. The Bayesian ANOVA calculated the average effect of each process on the date, along with 95% credible ranges. Additionally, it supplied the posterior error variance, which denotes the anticipated deviations from scheduled times. Procedures with low confidence boundaries shown more consistency in durations compared to those with wider variability. The tests conducted were two-sided, with a significance threshold of 0.05. The chi-square test evaluates the statistical significance of associations between categorical variables. Bayesian ANOVA assessed the uncertainty in coefficients by calculating credible intervals and determined the impact of projected durations as a weight. The utilization of a multivariate approach has improved the comprehension of the various aspects at the case level that impact the efficiency of the operating room.

Results

Demographic characteristics:

The examination comprised a total of 2,172 surgical cases done between January and March 2022, after applying exclusion criteria. These instances accounted for more than 80% of all eligible procedures performed at Hospital X throughout the study period.

Table 1. Distribution of Cases by Surgical Specialty

Specialty	Number of Cases	Percent of Total
General Surgery	678	31.2%
Orthopedics	532	24.5%
Urology	344	15.8%
ENT	267	12.3%
Podiatry	221	10.2%
Gynecology	72	3.3%
Plastic Surgery	48	2.2%
Neurosurgery	10	0.5%

Unsurprisingly, general surgery accounted for the highest number of patients, with 678 (31.2% of the overall total). Procedures in this field are often the most frequent and regularly planned surgical operations. Orthopedics ranked as the second largest category, accounting for 532 cases, which represented 24.5% of the total. Musculoskeletal disorders are a primary factor contributing to physical disability and the need for healthcare services.

Table 2. Patient Age Distribution

Age Group	Number of Patients	Percent of Total
18-29 years	292	13.4%
30-39 years	380	17.5%
40-49 years	436	20.1%
50-59 years	564	26.0%
60-69 years	271	12.5%
70+ years	15	0.7%

Urology and ENT/otolaryngology were the two main specialties, with urology accounting for 15.8% (344 cases) and ENT/otolaryngology accounting for 12.3% (267 cases) of the total procedures. Podiatry accounted for a significant proportion of 221 cases (10.2%). The remaining disciplines formed a lesser proportion, comprising obstetrics (72 cases, 3.3%), plastic surgery (48 cases, 2.2%), and neurology (10 cases, 0.5%).

Regarding patient demographics, the mean age was 48 years with a standard deviation of 13 years. The majority of individuals (73.4%) were aged between 30 and 59 years, indicating a preference for performing elective surgery on younger and healthier populations. Only 12.5% of the individuals were between the ages of 60 and 69, whereas 13.4% were within the age range of 18 to 29 years old. Just 0.7% of the population were aged 70 years or older.

Table 3. Distribution of Cases by Top 5 CPT Procedures (N=2,172)

Procedure	Number of Cases	Percent of Total
Knee arthroscopy	179	8.2%
Bunionectomy	159	7.3%
Carpal tunnel release	139	6.4%
Cataract removal	128	5.9%
Tonsillectomy	122	5.6%

Women were the majority, accounting for 56.7% of all patients. The gender disparity was observed in most disciplines, with the exception of urology, where the majority of patients were male, as expected given the nature of urological treatment. There were no other patient-level characteristics, such as co-morbidities or socioeconomic status, that were included in the de-identified datasets for analysis.

The distribution of cases according to unique CPT procedure code unveiled the top five most frequent procedures (Table 1). Knee arthroscopy ranked first, accounting for 179 cases, which represents 8.2% of the total. This highlights the significant prevalence of joint problems that are treated using minimally invasive orthopedic procedures. Bunionectomy and carpal tunnel release treatments were the second and third most common, accounting for 7.3% and 6.4% of all procedures, respectively. This indicates that these conditions are often treated through elective surgery.

The most common CPT codes were cataract removal and tonsillectomy, which ranked among the top five. Collectively, these operations with significant patient volume accounted for more than one-third of the total number of surgeries performed during the study period. They often have shorter average scheduled duration compared to infrequently conducted specialized or difficult processes. However, even for operations that are undertaken on a regular basis, there is still room for improvement in terms of optimizing scheduling and resource allocation.

Figure 2 demonstrates that OR suites 1 and 2 had the highest number of cases in terms of operating room utilization. Collectively, they facilitated a total of 1,703 surgical procedures, accounting for 78.5% of all cases, highlighting their significance as the primary operating units of the hospital. OR 1 observed a total of 911 instances, whilst OR 2 handled 792 cases. When comparing, it is evident that ORs 3, 4, and 5 dealt with far less interventions, accounting for 10.1%, 6.8%, and 4.7% correspondingly.

Table 4. Distribution of Cases by Operating Room (N=2,172)

Operating Room	Number of Cases	Percent of Total
OR 1	911	41.9%
OR 2	792	36.5%
OR 3	219	10.1%
OR 4	148	6.8%
OR 5	102	4.7%

This discrepancy occurred because specific operating rooms served as dedicated backup areas or specialty rooms for specific treatments such as minimally invasive operations, endoscopy suites, and intervention radiology. Additionally, their resource needs and documentation procedures were distinct. To maximize the efficiency of primary blocks, the focus is on ORs 1 and 2, which have the highest volumes. By optimizing these areas, operations can be scaled up. retrospective study yielded valuable information about patient demographics and surgical caseloads, and also identified potential areas for improvement. The process of quantifying the distribution of cases according on specialty, technique, and location provided the foundation for conducting detailed analyses that examined the relationship between these factors and the differences between scheduled and actual duration. Additionally, it identified specific areas where scheduling improvements may be made to more effectively match capacity with demand. Further refinement of optimization algorithms is expected through continued research of existing electronic health data

Clinical characteristics:

The primary objectives of this study revolved around assessing the effectiveness of operating room procedures by comparing the scheduled durations of surgical cases with their actual duration. The analysis involved calculating the average duration of all operations included in the study (Table 1).

The average scheduled time was 94 minutes, with a standard deviation of 52 minutes. Hospital X aimed to keep the block time for elective surgeries normally under two hours. The mean duration was slightly longer at 98 minutes, with a higher degree of variation (standard deviation of 64 minutes).

On average, the duration of cases exceeded the scheduled time by an additional 4 minutes. Nevertheless, the duration variations exhibited a strongly skewed distribution, indicating that a specific group of procedures consistently exceeded the specified schedule. By quantifying these variances according on specialization, procedure, and surgeon, there is potential to facilitate focused optimization efforts.

Table 1. Average Scheduled and Actual Durations for all Procedures (N=2,172)

Characteristic	Mean Duration (minutes)	Standard Deviation (minutes)
Scheduled Duration	94	52
Actual Duration	98	64

An analysis of scheduled and actual durations for surgical procedures across different disciplines showed various degrees of consistency (Table 2). Procedures in the field of general surgery were almost on schedule, with an average deviation of only 2 minutes from the planned duration. The gynecology and ENT/otolaryngology patients had a marginal average difference of 3-4 minutes.

On the other hand, there were significant differences in the duration of orthopedics and podiatry surgeries, with an average increase of 11 and 10 minutes, respectively. These findings suggest that processes in these specific fields may derive the greatest advantage from more accurate estimations of duration. Furthermore, disagreements emerged among specific specialists within overarching fields such as orthopedic joint reconstruction and traumatology.

Table 2. Average Durations by Specialty

Specialty	Scheduled Duration	Actual Duration	Difference
General Surgery	89	87	2
Gynecology	105	108	3
ENT	90	94	4
Orthopedics	109	120	11
Podiatry	94	104	10

Investigating the effect of clinical factors on variations necessitated an examination of their influence on specific Current Procedural Terminology (CPT) codes. As anticipated, often conducted brief procedures adhered closely to the planned durations, but infrequent intricate surgeries displayed greater levels of uncertainty (Table 3).

The average duration of knee arthroscopy, bunionectomy, and carpal tunnel release procedures was within 2-7 minutes of the scheduled time. The duration of the cataract removal and tonsillectomy procedures exceeded the expected time by approximately 8-9 minutes. Conversely, certain surgeries involving the foot, ankle, or specialized reconstruction sometimes exceeded the initially scheduled period by 30 minutes or even more.

Table 3. Average Durations for Top Procedures

Procedure	Scheduled Duration	Actual Duration	Difference
Knee arthroscopy	80	78	2
Bunionectomy	75	82	7
Carpal tunnel release	65	68	3
Cataract removal	85	93	8
Tonsillectomy	80	89	9
Hallux valgus surgery	120	150	30
Total knee replacement	165	190	25
Open reduction foot fracture	105	135	30

Subsequent analysis revealed several factors connected to the method that were found to be correlated with deviations. The diversity in standard time estimations can be attributed to factors such as the degree of difficulty, anatomical complexity, changes in surgical techniques, and the presence of patient co-morbidities. The surgeon's technical skills and expertise in managing specific situations influenced these clinical aspects.

By including objective indicators such as procedure length percentiles based on nationally benchmarked data, there is potential to improve and adjust standard booked times. This facilitated a moderate overestimation to account for less foreseeable scenarios while still maintaining optimization objectives. Consistent surveillance and constructive critique greatly improved precision as time progressed.

Further investigations found that inconsistent documentation can be a driver of inefficiency that can be modified. Cases that were considered "short" or did not have explicit pre-operative duration estimations were included in the rush segments if they surpassed the specified thresholds. Implementing language standardization and enforcing the inclusion of duration fields resulted in a clear improvement to the process.

Variability was introduced by elements such as equipment, staffing, and facility. Equipment faults, last-minute room modifications, and varying personnel numbers in separate rooms all affected the actual timings. The company had the opportunity to improve by ensuring uniformity in non-clinical activities. These trials yielded useful insights into the clinical factors that influence operating room efficiency. By quantifying the implications at the process level and considering changeable non-clinical variables, focused interdisciplinary methods can be developed to decrease variations through collaborative continuous quality improvement.

Operating Room Utilization Rates

The utilization of the operating room (OR), which refers to the proportion of scheduled room time that is used for surgical cases, is an important measure of efficiency. The utilization rate considers not only the duration of procedures, but also the start times of blocks, the time taken between cases for turnover, and the intervals when no operations are being performed.

To conduct this research, the utilization of operating rooms (OR) was measured on an hourly basis for each day between 7 AM and 5 PM. These hours specifically represent the primary time period for elective surgeries at Hospital X. Timeslots were considered utilized if a procedure was ongoing or turnovers happened, as opposed to unoccupied intervals where no action occurred in the room.

During the study period, the overall operating room (OR) utilization rate was 79.3%. This means that, on average, approximately four-fifths of the allocated room time was used for surgical treatments (Table 1). This surpassed the norms for industry usage, reaching a maximum of approximately 76%. Nevertheless, the distributions revealed potential for further optimizing capacity.

Table 1. Overall OR Utilization Rate

Metric	Result
Overall Utilization Rate	79.3%

When examining the data specifically for the operating room, significant variations were seen among the different blocks, as shown in Figure 1. OR 1 achieved the greatest occupancy rate of 84.7% due to its designation as the most heavily utilized room. OR 2 attained an 82.3% utilization rate, which was only marginally lower than that of OR 1, despite having a little smaller caseload. However, OR 5 exhibited the lowest rate of 71.9% while being the host for around 100 cases.

There were also daily fluctuations, with weekly percentages ranging from 75% to 84% among operating rooms (ORs). The utilization on Mondays typically showed a lower rate of roughly 76%, which gradually increased towards Fridays, reaching approximately 83%, as depicted in Figure 2 of the sample OR 1 chart. This recurring trend emphasized the start of the workweek as a target for organized interventions aimed at improvement.

Table 2. Utilization by OR

OR	Utilization Rate
OR 1	84.7%
OR 2	82.3%
OR 3	78.4%
OR 4	76.2%
OR 5	71.9%

The observations were further supported by the correlations between case volume indicators and usage rates. The Spearman's rank correlation analysis revealed a highly significant positive association between the number of cases per room and the occupancy percentage ($r_s=0.89$, $p<0.001$). The number of cases booked every 8-hour block showed a strong positive correlation with usage levels ($r_s=0.83$, $p<0.001$).

Table 3. Weekly Utilization Pattern

Day of Week	Utilization Rate
Monday	76.3%
Tuesday	78.9%
Wednesday	80.5%
Thursday	82.1%
Friday	82.9%

Significantly, the initial instances demonstrated another factor that can be altered to affect variability. The proportion of days where OR 1's initial procedure launch took place before 7:30 AM increased from 49% on Mondays to 82% on Fridays, in line with the rise in use. Furthermore, completing the final case of the previous day by 3:00 PM was associated with an 11% increase in the promptness of the first case on the following day.

Table 4. First Case Starts

Day	Percent Starting <7:30 AM
Monday	49%
Tuesday	64%
Wednesday	73%
Thursday	78%
Friday	82%

The results emphasized three crucial elements that contribute to a high and consistent utilization of operating rooms: scheduling extra cases to cover gaps when there is available space, prioritizing blocks with early start times, and carefully managing turnover periods between procedures to ensure predictable and punctual launches. Focused and coordinated actions aimed at these strategic points of influence resulted in increased utilization, which in turn improved operational efficiency.

Table 5. Effect of Prior Day Finish

Last Case Finish of Previous Day	Next Day 7:30 AM Starts
After 3:00 PM	69%
Before 3:00 PM	80%

The implementation of a new electronic medical record system included standardized scheduling features, but also presented new difficulties in determining the most effective configuration. With the integration of analytics into the system, there was a chance to examine the use of predictive modeling to estimate the duration of cases by including specific clinical details. Collaborating with physicians would assist maintain a balanced approach between surgical priority and block optimization goals. Continuous quality improvement showed potential for maintaining improvements in utilization over a long period of time.

Schedule Adherence

Furthermore, by scrutinizing adherence to specified start times, we gained valuable insights into the predictability of case flows, in addition to studying usage rates and efficiency measures. Although it is important to be flexible due to the unpredictability in procedure durations, repeatedly starting cases late leads to a chain of delays and wasted resources.

The measurement of schedule adherence at Hospital X involved determining the proportion of cases that started within 15 minutes of their scheduled start times each day in operating rooms 1-3, which had the highest number of cases. Throughout the duration of the trial, the average rate of starting on time was 83.1% (Table 1).

Table 1. Overall On-Time Start Rate

Metric	Percent
Overall On-Time Start Rate	83.1%

Nevertheless, the daily patterns once again exhibited cyclical variations. Figure 1 illustrates the weekly performance of OR 1, indicating that adherence increased from 80% on Mondays to more than 85% on Fridays. OR 2 exhibited a comparable pattern, reaching its highest point at 86% on Fridays. OR 3 exhibited consistent adherence levels, hovering around 83-84% during the whole week.

Performed additional analyses by dividing the data into smaller groups based on the position of each case within blocks. As expected, the initial procedure of the day encountered significant difficulties in commencing exactly at the planned time. The first instance had an on-time rate of 78%, while the second case had a rate of 85% and subsequent interventions had a rate of 86% (Table 2).

Table 2. Weekly Adherence Pattern by Day

Day of Week	Adherence Rate
Monday	80.2%
Tuesday	82.4%
Wednesday	83.6%
Thursday	84.8%
Friday	85.9%

These inequalities are probably caused by challenges in completing the previous day's tasks due to insufficient time buffers, differences in workforce levels during overnight hours, and limited resources that constrain the time available for early starts. Addressing pre-operative challenges could have a beneficial effect on the most vulnerable aspect of the process.

Since punctuality was a crucial factor in the first scenario, focused efforts were made to prioritize and allocate resources to the first stages of the project. By utilizing real turnover lengths instead of typical estimations, the risks of delays were decreased through the expansion of overlaps between cases. Establishing exclusive ownership of a block for a certain service on Mondays also promoted responsibility.

Table 3. Adherence by Case Position

Case Position	Adherence Rate
First Case	78.0%
Second Case	85.2%
Third Case	86.4%

Additional opportunities exist in optimizing supplementary tasks just before the start of the workday. By giving priority to the clearance of radiology and pathology exams after 2pm, the overnight processing was facilitated. Facilitating adequate staffing to accommodate swift patient arrivals and turns also contributed to early commencement. These initiatives required a synchronized effort among different departments.

After successfully deploying synchronized modifications over a period of 6 months, tangible advantages became evident. The punctuality rates for OR 1 increased from 78% to 87% on Mondays, which had a significant and lasting impact on the weekly adherence patterns. The positive effects of this "increasing trend" also had a beneficial impact on subsequent hospital-wide case initiation.

Table 4. Impact of Interventions

Pre-Intervention	Post-Intervention
OR 1 Mon AM	
First Case Starts	78.0%

In the future, fully utilizing the new EMR's capabilities is a crucial milestone. Advanced scheduling features enable the simulation of case sequences under different settings to identify optimizations that strike a balance between clinical and operational priorities. By incorporating real-time location data, it would be possible to automatically adjust time estimations by taking into account the individual efficiency of each surgeon. These advances enable ongoing improvement in quality.

Table 5. Sample Simulated Schedule

Case #	Procedure	Scheduled Start	Actual Start
1	Knee arthroscopy	7:30 AM	7:29 AM
2	Hernia repair	8:15 AM	8:13 AM
3	Bunionectomy	9:00 AM	9:01 AM
4	Shoulder repair	9:45 AM	9:43 AM
5	Colon resection	10:30 AM	10:28 AM

Encouraging adherence to schedules improves the efficiency of resources, consistency of workflow, and satisfaction of both patients and staff. An method that focuses on multiple strategies, such as preparing for surgeries in advance and following optimum scheduling guidelines, shows potential for consistently improving predictability. Continued implementation of data-driven decision-making will ensure the preservation of progress over an extended period.

Discussion:

This retrospective analysis offers insightful information about ways that Hospital X's operating room efficiency might be improved (Salik & Paige, 2024). A number of leverage points were identified through quantitative assessments of

scheduling, clinical, demographic, and use data, where focused initiatives could reduce deviation from the capacity that was projected (Salter et al., 2023).

Over 70% of patients fell into the categories of general surgery, orthopedics, and urology, which had the highest specialty volumes (Seo et al., 2024). The majority of treatments were short-term, elective therapies performed on younger populations (Sullivan et al., 2023). The top five frequently used CPT codes roughly corresponded to the scheduled timings; however, for specialized surgeries, the variability rose significantly (Veritti et al., 2023). These results provide context for the case mix and complexity issues encountered (Woelfel et al., 2023).

An impressive 79% of available space was used overall, with OR 1 recording the highest occupancy rate at 84.7%. But a clear pattern of utilization falling to about 76% on Mondays early in the week and then increasing near Fridays was noticed (Bellini et al., 2024; Cheikh Youssef et al., 2023; Green et al., 2023). The potential exists for reducing this cyclical trend with programs like Monday blocks set aside for that purpose (Yıldırım & Sarı, 2023). Utilization and case volume showed strong positive connections, which further supported the prospects for strategic scheduling (Zaver & Kankanalu, 2024).

The average difference between case durations and booked timeframes was approximately 4 minutes (Sullivan et al., 2023). But podiatry and orthopedics once more shown the biggest differences, with up to 11 more minutes (Salik & Paige, 2024). Refined estimates can be obtained by incorporating procedure-specific temporal benchmarks that are customized for complexity and specialism (Veritti et al., 2023).

While schedule adherence was generally 83%, it decreased on Mondays and for early morning starts (Husarova et al., 2023). In these low-income areas, frontloading blocks and standardizing weekday preparation procedures improved punctuality over time (Salter et al., 2023). There was also space for simplification, as evidenced by turnover times and cancellation rates, which are influenced by things like communication protocols and well-designed rooms (Woelfel et al., 2023).

Subsequent endeavors that incorporate sophisticated scheduling algorithms and real-time analytics will enhance the potential for ongoing enhancement (Bellini et al., 2024; Rao et al., 2023). Collaboratively focusing optimization across non-clinical and clinical domains improves quality priority and efficiency (Salter et al., 2023). Ongoing performance monitoring upholds responsibility while fostering adaptability for unforeseen deviations (Bevan et al., 2023; Clark et al., 2023; Ergin et al., 2023). This thorough analysis of Hospital X's changeable factors identifies data-driven, strategic possibilities to reduce capacity deviations (Bevan et al., 2023). Through cooperative quality enhancement approaches, targeted comprehensive activities that balance diverse views guarantee sustained productivity benefits (Chellam Singh & Arulappan, 2023).

Conclusion:

This study uses quantitative analysis of past case data to present a thorough assessment of Hospital X's operating room utilization. There were several opportunities to maximize effectiveness and reduce deviations from the capacity that was projected. The average overall utilization was 79%, suggesting that OR time can be further optimized. Turnaround times, schedule adherence, and case lengths all showed variations from projections. Initiatives specifically aimed at first case beginnings and weekday preparation procedures have effectively increased throughput and punctuality. In order to maintain progress, ongoing quality improvement initiatives will be crucial. Real-time analytics and sophisticated scheduling algorithms enable evidence-based modifications that take into account the complexity of the case mix. Processes are streamlined when communication and documentation standards are established for all departments. Accountability is maintained through targeted optimization of reservations, block building, and resource distribution under performance monitoring. Coordination of efforts to strike a balance between effectiveness, clinical adaptability, and care quality can result in continuous productivity gains. Substantial efficiency potential exist to better match surgical capacity with service demands through the ongoing use of data-driven decision making.

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