Analyzing Block Scheduling Heuristics for Perioperative Scheduling Flexibility: A Case Study Perspective

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Abstract
This study examines data mining as an extension of heuristic development to support continuous process improvement in perioperative scheduling. This paper identifies how dynamic technological activities of synthesis, analysis, and evaluation can highlight complex relationships within integrated information systems through existing patterns of associated organizational data. The identification of data patterns and subsequent human contextual understanding are contributing factors that yield opportunity for and re-enforce continuous process improvement within the perioperative services of a hospital. Based on a 72-month longitudinal study of a large 909 registered-bed teaching hospital, this case study investigates the impact of data mining to identify, qualify, and quantify block scheduling heuristic rules that improve perioperative scheduling flexibility. The theoretical and practical implications and/or limitations of this study’s results are also discussed with respect to practitioners and researchers alike.

1. Introduction
Perioperative services provide surgical care for inpatients and outpatients during immediate pre-operative, intra-operative, and immediate post-operative periods. From a hospital’s operational perspective, specialized perioperative services require multidisciplinary, cross-functional surgical teams to maneuver within a complex, fast-paced, and critical environment—the hospital environment [21]. As a result, perioperative services are tightly coupled to patient flow, patient safety, patient quality of care, and stakeholder (i.e. patient, physician/surgeon, nurse, and perioperative staff) satisfaction. Similarly from a hospital’s financial perspective, perioperative services are typically the primary source of hospital admissions, averaging between 55 to 65 percent of overall hospital margins [24]. Managing and optimizing flexibility within a hospital’s perioperative services are critical success factors (CSFs), both operationally and financially, given the current economic environment, the rising cost of healthcare, and the public demand for healthcare transparency and accountability.

Organizational data represent business processes and organizational importance that is embedded within information systems (IS). For this reason, IS and information technology (IT) have had and continue to have increasingly greater roles in the healthcare industry [11], [18], [19], [25]. With regards to performance toward CSFs, an integrated IS offers salience because it provides both the means and metrics for measurement. With regards to mining perioperative data for schedule flexibility, an agile IS contains the data that describe the heuristic rules and/or business processes to synthesize the desired results. However, Wears and Berg [33] notes that IS and/or IT only yield high-quality healthcare when the use patterns are tailored to knowledge workers and their environment. Hence, clinical scheduling IS that exhibit integration and agility would reflect present and potential business processes in its data to develop heuristic rules to improve perioperative scheduling.

This study examines the impact of data mining to identify, qualify, and quantify block scheduling heuristic rules that improve perioperative scheduling flexibility. The case results are facilitated by empowered individuals driven by integrated organizational data. The investigation method covers the longitudinal study of an integrated clinical scheduling information system (CSIS) within the perioperative services of a large, teaching hospital. The implementation of an agile CSIS and subsequent contextual understanding of perioperative scheduling patterns within the CSIS prescribed the need to redesign the perioperative scheduling process by introducing heuristic rules to increase block scheduling flexibility. Specifically, the extension of
data mining into the analysis and evaluation process of CSIS’ data provides the framework for the discovery and synthesis of new block scheduling rules within perioperative services. The implementation of the newly synthesized scheduling process, along with changes in the perioperative services, began the change dynamics for mining additional data patterns to discover and synthesize additional heuristic rules. This case study also identifies the complex dynamics associated with perioperative scheduling in the hospital environment.

The following sections review previous literature on data as a resource, data mining, and surgical specialty block scheduling. By identifying a holistic model for evaluation, analysis, and synthesis between data and heuristic block-scheduling process design, this paper prescribes an a priori environment to support flexibility in perioperative scheduling. Following the literature review, we present our methodology, case study background, as well as an analysis of the observed effects from heuristic rule changes to perioperative block scheduling. The conclusion discusses implications and limitations of this study.

2. Data, design, and data mining

Data is a prerequisite for information, where simple isolated facts are given structure through IS design to become information. Early in the IT literature, Ackoff [1] proposed IS design should embed feedback as a control to avoid management misinformation. Zani [37], Rockart [27], along with Munroe and Wheeler [23] proposed the selection and supervision of defined data as key performance indicators (KPIs) to assist management in qualifying data needs against CSFs and subsequently manage organizational action (i.e. business processes) through IS feedback. Similarly, healthcare processes within perioperative services are becoming increasingly information intensive and doubt exists as to whether perioperative process management is fully understood to meet the increasing hospital environmental demands for value and cost management [9]. Understanding how CSIS design embeds processes into data input and information output is a first step toward understanding data as a resource for heuristic development [4].

Given that people perform organizational action, people develop IS, people use IS, and people are a component within IS [29]; understanding the human mind is a requisite in understanding how organizational action via CSIS occur. Ackoff [2] proposed a content hierarchy of the human mind, where each content category is an aggregate of the categories below it. Wisdom descends to understanding, knowledge, information, and then data. Other authors of knowledge management literature share similar hierarchical views of human mind content [16], [12], [31].

Achieving wisdom requires successively upward movement through the other four human mind content categories, with each level drawing content from prior levels. Data, information, knowledge, and understanding relate to past events and wisdom deals with the future as it incorporates vision and design.

The IT literature contains volumes of studies to offer opinions on system design. For this study, the intent is to provide a basic understanding of system design activities and substantiate the need for iterative improvement through heuristic development. Blanchard and Fabrycky [6] recognize system design as a requisite within the systems life cycle, where technological activities of synthesis, analysis, and evaluation are integrated within iterative applications to minimize systems’ risk from entropy, obsolescence, and environmental change.

Under ideal terms, an individual’s wisdom recognizes that an organizational need requires an IS solution. Subsequently, individual understanding and knowledge create the IS design, develop the IS, and implement it to meet the organizational need. This ideal situation is hypothetical, yet it does illustrate that during the design, development, and implementation stages of an IS (i.e. the systems life cycle), understanding, knowledge, and information are decontextualized into detached data and semantic data structures that are accessible by IS’ processes. Tuomi [31] called this set of human mind sequences a reversed hierarchy from the traditional model (i.e. data leads to information and then on to knowledge, understanding, and wisdom).

Ackoff [2] concluded that wisdom might well differentiate the human mind from the IS. Consequently, it is understanding and knowledge of the business process that system stakeholders use to develop information requirements and subsequent data requirements for IS design. Furthermore, in reverse logic it is data within the implemented IS that knowledge workers can use to assist in the organizational action of discovery to develop the knowledge and understanding of how to redesign business processes. Jon Udell [32] compared data to Play-doh—a tangible substance that can be squeezed, stretched, and explored directly. Witten and Frank [35] define data mining as the process (i.e. automatic or semiautomatic) of discovering patterns (i.e. structure) within data, where the data already exists within the IS’ databases in substantial quantities and
the discovered patterns have organizational importance.

Data mining can explore raw data to find organizational and environmental connections (bottom up), or search data to test hypothesis (top down) producing data, information, and insights that add to the organization’s knowledge [10]. Data mining uses the traditional model of the human mind to churn data, existing within the IS, into information that leads on to knowledge, understanding, and possibly wisdom. Unfortunately, the healthcare industry has not fully embraced data as a resource and utilized data mining as a knowledge discovery tool [34], [9], [13] [20], [26].

With respect to this study, data mining techniques are applied within a perioperative data mart to identify heuristic block scheduling rules that increase the flexibility of perioperative scheduling. Online analytical processing (OLAP) and data visualization of perioperative scheduling data compared to capacity constraints allow the pattern recognition of scheduling anomalies, which in turn trigger and justify the synthesis of improved heuristic rules within the block scheduling review. Specifically, the anomalies identified included nursing staff shortages, surgeon shortages, under-utilized rooms, under-utilized robotic equipment, over allocation of block time to surgical specialties, and double booking of surgical cases. The heuristic rules reassigned nursing staff, closed and opened ORs to compensate for capacity constraints, and reallocated surgeons’ blocks of OR availability based on history and the number of days before the scheduled surgical case.

2.1 Holistic model for heuristic development

Figure 1 depicts a holistic model that supports the heuristic development of perioperative block-scheduling rules. Perioperative data captured by the CSIS and stored in a data mart is available for heuristic development. The stored perioperative data represents the current and historical perioperative actions (i.e. perioperative services extended to patients). Using the reversed hierarchy [31], perioperative knowledge workers extend the CSIS design through OLAP and data visualization to analyze data patterns for meaningful structure. Evaluation of the meaningful data pattern structures leads to synthesis (i.e. redesign) of improved or new block scheduling rules. Implementation of the new or improved block schedule is later reflected in the perioperative data mart, which restarts the analysis, evaluation, and synthesis cycle. The model depicts the iterative nature of heuristic development.

2.2 Perioperative block schedule

Providing effective surgical care demands a high level of planning, scheduling, and proactive efforts to minimize delays and last-minute cancellations of surgeries or procedures [28]. As a first step in effective planning, a “block schedule” is a formal plan for allocating perioperative resources (e.g. operating room suite, staffing, and equipment) for surgical specific services (SSS). McIntosh, Dexter, and Epstein [22] note that SSS may be specific clinical disciplines in the medical staff structure or the activities of surgeons (individuals or groups) who use the hospital’s perioperative services and thus require organized staffing to support their activities. Unfortunately, block schedules of perioperative resources are often built around surgeon or clinic schedules, surgeon or SSS seniority, and other preferences that are established outside of the perioperative or hospital environment [14]. The healthcare literature supports block scheduling to minimize variability in perioperative services as well as releasing or modifying block scheduled resources based on historical perioperative workloads [8], [14], [22], [5].

2.3 Perioperative critical success factors

Key performance indicators (KPIs) in managing and optimizing perioperative services are monitoring the percentage of surgical cases that start on-time (OTS) and the number of first-of-the-day surgical cases (FCOD_OTS) that start on-time [3]. OR schedules are tightly coupled to the individual OR suites and surgeon. When a prior case runs over or a surgeon is not available to start the next case, the subsequent case schedule of the particular OR suite or particular surgeon falls behind.
Poor KPIs on either metric (i.e. OTS or FCOD_OTS) impact critical success factors of patient safety, patient quality of care, surgeon/staff/patient satisfaction, and hospital margin [3], [24], [30]. The Thomson Group [30] also noted that physician/surgeon satisfaction, a critical success factor for hospital margin, is also impacted by OR suite turnover time between cases and a flexible, efficient perioperative work environment.

3. Research method

The objective of this study is to investigate the impact of data mining to identify, qualify, and quantify block-scheduling heuristics that improve perioperative scheduling flexibility. The case results are facilitated by empowered individuals driven by integrated organizational data. To this end, case research is particularly appropriate [17], [36]. An advantage of the positivist approach [33] to case research allows concentrating on a specific hospital service in a natural setting to analyze the associated qualitative problems and environmental complexity. Hence, our study took an in-depth case research approach.

Our research site is a large teaching hospital (University Hospital), licensed for 909 beds and located in the southeastern region of the United States. University Hospital is one of two magnet hospitals in the state and the U.S. News and World Report recognized University Hospital as a Best Hospital in 16 of the last 18 years. Concentrating on one research site facilitated the research investigation and allowed the continued collection of longitudinal data. This study spans activities from 2003 to 2010. During the 72-month study, we conducted field research and gathered data from multiple sources including interviews, field surveys, site observations, field notes, archival records, and documents reviews.

The perspective of this research focused on University Hospital’s perioperative scheduling practices for its 32 general perioperative suites from November 2004 through April 2010. During this time span, University Hospital’s perioperative services CSIS broadened its scope to include three other perioperative services within the University Hospital System. The cardio-vascular suites and two off-site surgical clinics constitute an additional 38 suites that were excluded from this research study to maximize the continuity in observing block schedule changes. For the same reason, this research focused on the following surgical specialty services (SSS) represented in Table 1.

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<thead>
<tr>
<th>Table 1 – SSS Categories</th>
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<tr>
<td>Surgical Specialty Service (SSS) Examined</td>
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<tr>
<td>BURN – Trauma burns</td>
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<td>ENT – Ear, Nose, &amp; Throat</td>
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<td>GI – Gastro-intestinal</td>
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<td>GYN – Obstetrics, oncology, incontinence</td>
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<td>NEURO – Neurological</td>
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<td>ORAL – Oral Maxil Facial</td>
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<td>ORTHO – Orthopedic, joint or device replacement</td>
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<td>PLAS – Plastic surgery</td>
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<td>SURG ONC – Surgical oncology</td>
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<td>TX – Transplants (liver, renal)</td>
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<td>TRAUMA – Trauma, MASH</td>
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<td>URO – Urology</td>
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<td>VASCA – Vascular - arteries</td>
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<td>VASCULAR – blood vessels</td>
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4. Results

Perioperative services implemented a new CSIS in 2003, after using its prior CSIS for 10 years. The old CSIS and its vendor were not flexible in adapting to new data collection needs of perioperative services. The old CSIS did not have advanced OLAP tools and the perioperative data mart was a collection of Microsoft Access databases. The new CSIS from vendor C was equipped with OLAP tools, a proprietary structured query language, and both operational and managerial data stores (i.e. operational data and a separate perioperative data mart). The new CSIS had flexible routing templates that could be customized (i.e. from 4 to 36 segments to capture point of care data) over generic and specific surgical procedures. The new CSIS was fully implemented by the end of 2003. Since its implementation, University Hospital has deployed over 300+ surgical procedural modifications across the SSS represented in Table 1.

![Figure 2 - IS architecture (October 2004)]
Figure 2 depicts University Hospital’s CSIS architecture for perioperative services as of October 2004. University Hospital had six main IS: (1) a large-scale hospital materials management IS, which included pharmacy, material and medical device management (Vendor L); (2) a large scale enterprise resource planning IS (Vendor O); (3) a patient record Admit/Discharge IS (Vendor Q); (4) a cost accounting IS (Vendor T); (5) a financial budgeting IS (Vendor H); and (6) a clinical scheduling IS (Vendor C) that included three modules for clinical scheduling, routing sheets, and cost data. All IS were integrated with uni-directional constraints placed on sensitive information. The institutional intranet served as portal access to extend each of the six IS. User authentication via the intranet was single entry with particular user IS rights and privileges negotiated upon authentication.

4.1 November 2004

University Hospital opened a new diagnostic and surgical facility in November 2004, which covers three-fourths of a city block rising 12 stories. Perioperative services were relocated into three floors, with operating rooms (ORs) located over two floors and Central Sterile Supply (CSS) located separately on the third. The move expanded perioperative services to cover an additional floor and nine additional ORs. The new facility housed 40 state-of-the-art OR suites (32 general OR), each equipped with new standardized equipment. Groups of SSS OR suites categorized a surgical specialty, with each particular room among the group containing specialty equipment. Within six weeks of occupying the new perioperative facility, scheduling metrics reflected chaos. On-time surgical case starts plunged to 18% during December 2004. Within a highly competitive hospital industry, having only 18% OTS was unacceptable. Within perioperative services, having 82% of scheduled surgeries backlogged risks patient care and safety.

Perioperative concerns were laid out before a quickly convened executive committee that included the chief executive officer, the chief financial officer, the chief information officer, the chief nursing officer, and top representatives of surgeons, anesthesia, CSS, and perioperative management. The meeting resulted in a new management structure and the formation of a cross-functional, multidisciplinary executive team who was empowered to evoke change. The executive team and numerous task forces formed to address specific problems and/or opportunities were chartered to focus on patient care and safety, attack difficult questions, and no issue was “off-limits.” The executive team was commissioned by executive officers to investigate the challenges and determine what were the underlying issues and the overall strengths of each issue. The team consisted of surgeons, nurse leaders, anesthesiologists, and perioperative management. The executive team and task groups were challenged to systematically identify issues and enlist working managers for solutions that would facilitate change and minimize departmental chaos.

4.2 Block schedule modifications

In November 2004, University Hospital allocated OR suites by SSS—scheduling blocks of time for an OR suite from 7 a.m. to 4:30 p.m., regardless of the SSS caseload. Scheduling OR suites by SSS assigned blocks did not reflect actual SSS cases within the scheduling blocks (i.e. the scheduling method did not reflect the OR data collected by the CSIS). The inefficient practice of block scheduling OR suites was directly attributable to University Hospital reaching 100 percent of capacity for its new perioperative facilities within six weeks of relocating, even though the new facility had increased existing OR room capacity by 33 percent. However, block scheduling a single OR suite was required. As a Level I trauma center, University Hospital must accommodate trauma patients 24/7, so the practice of block scheduling one of the general OR rooms was retained, specifically for trauma patients.

The actual OR hours used by SSS cases (i.e. SSS case loads) from the data mart were analyzed against OR hours allocated to each SSS block assignment. The resulting data patterns showed the need to redesign the OR scheduling process. As a result of the analysis, a straight SSS block assignment was discontinued. Given that physician satisfaction is linked to OR block scheduling by SSS [24], block assignments were kept for outside-of-a-week planning purposes. However, the block assignments of OR suites were modified to reflect the actual SSS caseload.

The perioperative scheduling heuristic review process routinely modifies the block scheduling rules by analyzing actual SSS case load versus respective SSS block schedule. SSS specific block release rules are established with consideration to the individual service’s patient population. Similar to marketing segmentation among demographic groups, SSS specific needs are considered along with historical data to establish predictable average SSS patient case loads. SSS with wide variability in scheduling are given consideration and a reduction in the number of early release blocks of OR suites.
Table 2 – Block Schedule Changes

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<th>Heuristic Block Scheduling Rule Modifications</th>
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Table 2 identifies each of the 23 modifications made to the heuristic block scheduling rules since November 2004. The heuristic rules identify which SSS by surgeon by room by weekday by scheduling block across the 32 ORs scheduled. Additional heuristics allow surgeons and SSS to alternate by week and by month.

The time span between modifications represents the data collection period used to evaluate the next SSS case load mix. The release time modifications were based on the number of days between a surgical case scheduled date and the date the case was entered into the CSIS. When a SSS fails to utilize 50% of an OR’s daily block during a review period, that OR block is available to be reallocated to another SSS. SSSs who utilize more than 80% of an OR’s daily block receive the reallocated block. The SSS block assignment heuristics have been remixed 14 times since the review process began in July 2005.

Please note that the first three modifications were changes to the block schedule heuristics that systematically closed 10 ORs evenly across SSSs to offset the nursing staff shortage created by the move to the new facility. When OR scheduling changed from a standard eight hours, heuristics were added that identified whether an OR was scheduled for 8, 10, or 12 hour blocks. The staff shortage constraint was resolved in July 2005 and a heuristic reopened the 10 closed ORs to the scheduling blocks. Another heuristic for staff shortage was added in November 2007 to compensate for surgeons taking leave. Lastly, heuristics were added when OR suite robots were installed to ensure room and robot utilization.

Given the slow learning curve associated with the OR relocation disruption, a new KPI was established to track surgical case OTS within 10 minutes. Figure 3 represents the surgical case OTS for December 2004 through May 2007 and the OTS within 10 minutes for October 2005 through May 2007.

In May 2007, the release of SSS block scheduled time began. Figure 4 illustrates the impact of heuristic rules in the modified block scheduling with release time over the straight SSS block scheduling. Current scheduling windows are beyond 14 days, 7 to 14 days, 1 to 7 days, 24 to 72 hours, within 24 hours, and day of surgery (DOS). It is interesting to note that in aggregate, within 24 hours trends with 1 to 7 days. Likewise, 14 days, 7 to 14 days, and 24 to 72 hours have trended together. DOS is less than 5% of scheduled cases. Over the last evaluation review period, 14 days has dropped and is trending toward DOS.
Figure 5 to Figure 10 are examples of the impact on individual SSS from the heuristic rules in the modified block scheduling with release time over the straight SSS block scheduling. In each of the SSS represented, the percentage of scheduled cases for scheduled less than 7 days out represent the majority of the cases scheduled. The impact of the heuristic modified block schedule with release increases the SSS flexibility, especially in the within 24 hours and 24 to 72 hour cases scheduled.

4.3 Summary of outcomes

Since the discontinuance of straight SSS block scheduling and the implementation of SSS block release rules (i.e. heuristic rules), the CSIS data mining has produced SSS block assignments for the outside-a-week planning horizon that reflect actual SSS case volume. Overall, 29.6% of the surgical cases performed (i.e. 97,481 cases) during our 66-month scheduling horizon were scheduled outside-a-week and only 2.7% of the cases were scheduled the day of schedule. Over two-thirds of the surgical patients during the 66-month horizon were scheduled during the week of their surgical procedure.
5. Analysis and discussion

The SSS block assignment revisions are accurate, based on recent SSS case data, which allowed an across SSS block release rule of 72-hours to the SSS division and 48-hours to any other SSS. In effect, the CSIS data mining of projected case loads by SSS was accurate in estimating how many blocks of OR suite time is needed for each SSS. Unscheduled SSS block time is released to other surgeons in the specialty division 72 hours out and 48 hours out to any surgeon.

The block release rules offer a tight coupling between CSIS projected block assignments and actual surgical cases. Across all SSS, University Hospital’s block release rules offer a looser coupling (i.e. more flexibility) than suggested SSS block release rules from Peters and Blasco [24]—releasing the SSS block 2 days out rather than 5 days out. The looser coupling is a function of the block release rules, with little trade-off to other KPIs of perioperative utilization or OTS. Figure 11 and figure 12 illustrate each of these University Hospital’s KPIs over the block scheduling with time release changes, respectively.

The KPIs from Figure 4 to Figure 12 reflect increased utilization, increased first case on time starts, and increased flexibility in less than a week scheduling windows on aggregate and by SSS. These metrics reflect improvement over time frames that experienced an average 10% increase in annual surgical case volume while maintaining a constant utilization around 80%. From our research data, 18.1% of the surgical cases were scheduled 24-hours to 72-hours out and 33.1% were scheduled within 24-hours of the surgical case start. The looser coupling gives University Hospital’s perioperative scheduling more surgeon flexibility, which is a critical success factor in surgeon/physician satisfaction [30].

The replacement of the straight SSS block scheduling rules with heuristic modified block scheduling with release time redesigned the scheduling process in perioperative services. Caccia-Bava, Guimaraes, and Guimaraes [7] identified determinants of business process redesign (BPR) success in hospital environments, which include: (1.) the cross-functionality of the project team; (2.) the process used by the project team to implement the BPR project; (3.) the expertise available to the project team regarding the processes being redesigned/reengineered; (4.) the quality of the IT support extended to the project; and (5.) the project leadership and motivation for the project. University Hospital’s perioperative services efforts in modifying block scheduling rules were successful and this study’s research did identify underlying themes similar to the determinants of successful BPR, which include:

1) The executive team was cross-disciplinary and represented all the perioperative stakeholders. In the development of the heuristics and additional modifications, all stakeholders were represented in the executive team decisions.

2) The process used by the project team to implement each block schedule change was very open to all stakeholders. No issue was above questioning and perioperative data patterns justified the block schedule modifications and resulting heuristic rules.

3) The expertise available to the executive team regarding the heuristic development was within perioperative services. The data for benchmarking the new KPIs were derived from the CSIS and national benchmarks.

4) The quality of the IT support extended during each CSIS modification or change was instrumental to each block schedule change. The whole redesign effort could not have been accomplished with the old CSIS, as it did not have the tools, agility, or space to collect the
perioperative data as needed. The new, agile CSIS was a critical success factor in adapting to routing changes and collecting varied perioperative data across multiple SSS. The ability of the new CSIS to add perioperative scheduling to off-campus and on-campus clinics with an additional 38 OR suites is an example of its agility and flexibility.

5) Perioperative management and all other surgical team’s management were the executive team, increasing the OR capacity and utilization was the motivation, and data mining efforts synthesized the heuristic rules resulting in the modified block schedule with time release results.

Overall, the heuristic discoveries from the CSIS’ OLAP tools did direct the redesign efforts in the perioperative scheduling processes as well as serve to identify KPIs for the performance measurement process. More importantly, the heuristic development and process synthesis efforts focused perioperative staff and surgical teams on using perioperative data as a resource—for continuous perioperative services improvement and scheduling flexibility.

6. Conclusions

Empowered individuals, integrated CSIS, and a holistic model for heuristic development improved the perioperative scheduling within University Hospital. Embracing the holistic model for heuristic development allowed perioperative stakeholders to discover, comprehend, and implement improved scheduling processes. The stakeholder synthesis, analysis, and evaluation stimulated communication, learning, and continuous improvement. Moreover, the heuristic development improved the perioperative environment. Patients were exposed to less risk associated with FCOTS. Anesthesiologists and surgeons, as scientists, gained better efficiencies and flexibility with the block-scheduling changes, which yielded more operating time, better research data, and less scheduling problems. Furthermore, nurses and perioperative staff gained increased communication, more flexible work schedules, enhanced work-life, and increased professional awareness.

Our case study contributes to the healthcare IT literature by investigating how mining perioperative data can synthesize the heuristic development of scheduling rules, using a prescribed a priori model to foster its occurrence. This paper also fills a gap in the literature by describing how hospital process data is a resource. This study was limited to a single case, where future research should broaden the focus to address this issue along with others that the authors may have inadvertently overlooked.

The case examples presented in this study can serve as momentum for healthcare data as a resource methodology, comprehension, and extension. While the results should be viewed as exploratory and in need of further confirmation, researchers may choose to extend or expand the investigation. Practitioners may apply the findings to create their own version of healthcare data as a resource within perioperative services or the larger hospital environment.

7. References:


