Seeking Operational Excellence via the Digital Transformation of Perioperative Scheduling

Completed Research

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Abstract

This study examines the digital transformation of perioperative scheduling within the hospital environment to achieve operational excellence. Based on a 181-month longitudinal study of a large 1,157 registered-bed academic medical center, the observed effects are viewed through a lens of information technology (IT) impact on core capabilities and core strategy to yield a digital transformation framework that supports patient-centric improvement across the scheduling of perioperative sub-processes. This research identifies existing limitations, potential capabilities, and subsequent contextual understanding to minimize perioperative process complexity, target opportunity for improvement, and ultimately yield improved scheduling capabilities. Dynamic technological activities of analysis, evaluation, and synthesis applied to specific perioperative patient-centric data collected within integrated hospital information systems yield the organizational resource for process management and control. Conclusions include theoretical and practical implications as well as study limitations.

Keywords

Digital transformation, operational excellence, business process management, heuristic rule-based scheduling, perioperative process.

Introduction

Integrated hospital information systems (IS) and information technology (IT) provide measurement and subsequent accountability for healthcare quality and cost that represent the foundation for healthcare improvement (Dougherty & Conway, 2008). Similarly, the Centers for Medicare & Medicaid Services' (CMS) Electronic Health Record Incentive Program (CMSEHRIP) has quickened the digital transformation of healthcare delivery across the U.S. healthcare ecosystem, in order to exploit the consensus that IT value propositions will improve healthcare quality and reduce costs (Agarwal et al., 2010). Furthermore, the Joint Commission on Accreditation of Healthcare Organizations (TJC), and CMS require periodic performance and clinical outcome reporting as evidence of organizational quality, efficiency, and effectiveness. Consequently, administrators and medical professionals alike must leverage IS and IT to yield quality patient care and safety, coupled with increased efficiency and cost effectiveness (PwC, 2012). The widespread healthcare IS/IT adoption from CMSEHRIP necessitates the need for realized value (Jones et al., 2014). However, successful digital transformation requires strategy on change management and application as well as technology implementation (Hess et al., 2016). Hence, this research study focuses on understanding health IT integration and use as these systems will have little impact on perioperative performance if not well integrated into daily healthcare providers' workflows (Agarwal, et al., 2010; Wears & Berg, 2005).

Within the hospital environment, patient care is the focus of work. To this end, a hospital's perioperative process involves multiple interconnected sub-processes that yield surgical care for inpatients and outpatients during pre-assessment, pre-operative, intra-operative, post-operative, and central sterile supply activities. Therefore, a hospital's perioperative process is complex (Fowler et al., 2008) and the complexity challenges multidisciplinary teams to maneuver within fast-paced and critical situations. Compounding factors of complexity and urgency affect patient quality of care, patient flow, patient safety, operational efficiency, as well as stakeholders' satisfaction (i.e., patient, physician, nurse, perioperative staff, and hospital administration). Financially, the perioperative process is typically the primary source of hospital admissions, averaging between 55 to 65 percent of overall hospital margins (Peters & Blasco, 2004). Other research shows 49 percent of total hospital costs are variable, with the largest cost category (i.e., 33%) being the perioperative process (Macario et al., 1995). Hence, IT value propositions via digital transformation can improve perioperative quality, efficiency, and effectiveness to ultimately impact hospital financial performance.

This research investigates complexity and change dynamics observed during a hospital's digital transformation of the perioperative scheduling process. The observed effects span a longitudinal study of an integrated clinical scheduling IS (CSIS) implementation, integration, and use. The systematic analysis and subsequent contextual understanding associated with the perioperative scheduling digital transformation prescribed opportunity for measured improvement. Specifically, this study investigates the research question as to how the digital transformation of a hospital's perioperative scheduling can yield operational excellence to enable improved patient flow, integrated hospital IS to workflow coupling, and stakeholder satisfaction.

The following sections review previous literature with respect to digital transformation, business process management (BPM), perioperative scheduling, and key performance indicators (KPIs). Following the literature review, we present our methodology, case study background, observed effects, and discussion. By identifying a holistic, heuristic-based perioperative scheduling framework via digital transformation, this study prescribes an a priori strategy for operationalization and replication. The conclusion also addresses study contributions, limitations, and implications.

Literature Review

Health IT capabilities have the potential to fundamentally transform healthcare services (Agarwal et al., 2010). However, the strategy as to how healthcare providers leverage and use the health IT capabilities will determine the level of digital business transformation success. Furthermore, Bhardawaj et al. (2013) defines digital business strategy as how an organization applies and uses IT yielding a fusion between IT strategy and business strategy. Earlier in the literature, Applegate et al. (2009) suggested organizations view core capabilities and core strategy combined through an IT lens to delineate between IT impacts on capabilities versus strategy. The resulting IT Impact Map, denoted in Figure 1, illustrates the four modes an organization can exhibit by varying IT impact levels on core capabilities versus strategy.

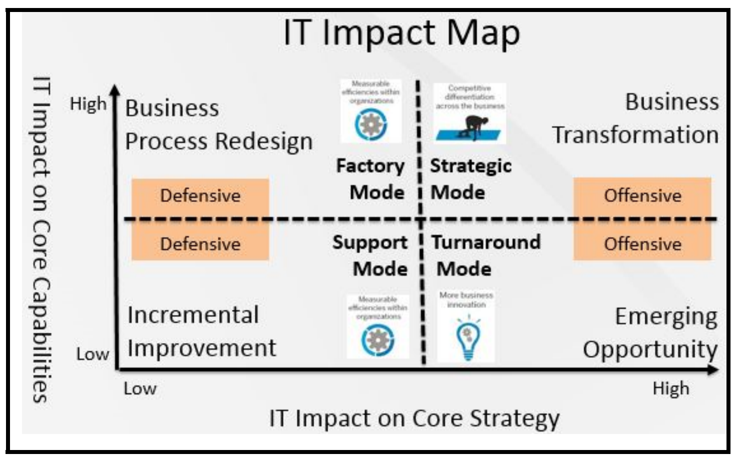


Figure 1 - IT Impact on Core Capabilities vs. Strategy
(Adapted from Applegate, McFarlan, & Austin, 2009)

With respect to Figure 1 in a hospital environment, the two modes labeled defensive represent health IT applications with internal hospital impact (i.e., measurable internal efficiencies), but low IT impact on core strategy. The two modes labeled offensive represent health IT applications with high IT impact on core strategy. The following subsections review previous literature on digital transformation, BPM, perioperative scheduling, and KPIs as related to IT impact illustrated in Figure 1.

Digital Transformation

Digital transformation is similar to the IT Impact Map's representation of defensive and offensive IT. Digital transformation is evolutionary and leverages digital capabilities with emerging IT to create value via business models, operational processes, and customer experiences (Morakayane et al., 2017). Re-phrased, digital transformation reflects the changes new IT makes in an organization to change products or services, organizational structures, and/or the automation of business processes (Hess et al., 2016). Moreover, simply implementing or using IT is not enough to achieve digital transformation (Andai-Ancion et al., 2003; Bharadway et al., 2013; Hess et al., 2016; IDG, 2018; Kane et al., 2015; Matt et al., 2015; Morakayane et al., 2017; Schadler et al., 2017; Sebastian et al., 2017). A key driver of digital transformation is the level of organizational digital maturity (e.g., higher is desired) found among organizational strategy, culture, and talent (Kane et al., 2015). Organizational culture, talent, and strategy develop over time, so digital transformation is evolutionary. Likewise, higher digital maturity yields more innovative IT success (Kane et al., 2015).

Schadler (2017) suggests digital transformation strategies focus on internal operational excellence (i.e., defensive IT impact) and external customer experience (i.e., offensive IT impact). At the organizational level, digital transformation strategies must consider financial aspects that balance IT use, value creation, and structural changes (Matt et al., 2015). At the patient level, digital transformation strategies have cross-functional characteristics, which require operational strategy alignment for complex coordination efforts due to multiple strategy interaction (Matt et al., 2015). An example of multiple strategy interaction is illustrated in the clinical use of IS and IT integration within acute critical care settings (Rothschild, 2004) to improve patient monitoring, bedside charting, and artificial support devices.

Business Process Management (BPM)

Continuous process improvement (CPI) is a systematic approach toward understanding process capability, customers' needs, and sources of observed variation. Tenner & DeToro (1997) views CPI as an organizational response to an acute crisis, a chronic problem, or an internal driver. CPI encourages bottom-up communication in day-to-day operations (i.e., patient level) and requires process data comparisons to control metrics. Incremental improvement (e.g., Figure 1) gains occur via iterative cycles of analysis, evaluation, and synthesis (i.e., plan-do-study-act; Walton, 1986) to minimize observed variation. Doubt can exist as to whether: the incremental improvement addresses symptoms versus causes; the improvement effort is sustainable year after year; or management is in control of the process (Jeston & Nelis, 2008). The IT Impact Map's incremental improvement mode (i.e., CPI) is invisible to external stakeholders over the short term.

Business process redesign (e.g., BPR Figure 1) offers more radical change when compared to CPI. Greater reward potential (e.g., 1,000%) with the highest risk, duration, cost, and implementation difficulty (Tenner & DeToro, 1997). BPR is rethinking and redesigning to achieve dramatic improvements in performance (e.g. cost, quality, service, and speed). BPR requires extensive resource allocations while seeking an order of magnitude improvement by questioning each activity's relevance and reinventing new ways to accomplish necessary work. With respect to the IT Impact Map, the BPR mode has core business processes online in real-time, yet IT impact provides little strategic differentiation.

CPI and BPR are tenets of BPM. Jeston and Nelis (2008) defines BPM as achieving an organization's objectives via improvement, management, and control of core business processes. The authors further elaborate that process management and analysis is integral to BPM, where there is no finish line for improvement. Hence, this study views BPM as an organizational commitment to consistent and iterative performance improvement that meets organizational objectives. Business analytics is the body of knowledge identified with technology solutions that incorporate definition and delivery of business metrics, performance dashboard management, as well as data visualization and data mining (Turban et al., 2004). Business analytics within BPM focus on the effective use of organizational data and information to drive positive business action (Tenner & DeToro, 1997). The effective use of business analytics demands knowledge and skills from subject matter experts and knowledge workers. BPM success has a strong dependence on stakeholders' understanding of core processes (Jeston & Nelis, 2008). Similarly, IS and/or IT only yield high-quality healthcare when use patterns are tailored to knowledge workers and their environment (Wears & Berg, 2005). To this end, BPM is applicable to either defensive or offensive health IT applications and the associated IT impact depicted in Figure 1.

Perioperative Scheduling

Specialized physicians (e.g., surgeons and anesthesiologists), nurses, and staff provide pre-operative, intra-operative, and immediate post-operative patient care. Hence, scheduling perioperative patient care requires awareness, communication, and coordination via teamwork with specific roles and activities. Surgeons evaluate, prescribe, and then perform the surgical procedure. Anesthesiologists evaluate, prescribe, and administer the induction-maintenance-emergence process of anesthesia (Arthur & Odo, 2010). Nurses evaluate, assist physicians, provide either ambulatory or acute care per physicians' orders, as well as monitor and record all patient care activity. Perioperative staffs facilitate location, supplies, instruments, and equipment per physicians' orders. As a result, perioperative care yields patient end-state goals: (1) a correct diagnosis for surgical intervention is identified with noted co-morbidities and patient consent; (2) a patient undergoes the surgical procedure; (3) a patient exhibits minimal exacerbation of existing disorders; (4) a patient avoids new morbidities; and (5) a patient experiences prompt procedure recovery (Silverman & Rosenbaum, 2009). However, workflow complexity is a barrier to perioperative patient end-state goals (Fowler et al., 2008).

Efficient and effective perioperative care demands a high level of planning, scheduling, and proactive efforts to minimize delays and last-minute cancellations of surgical procedures. As a first step in planning, Peters and Blasco (2004) note that a "block schedule" is a formal plan for allocating perioperative resources (e.g. operating room suite, staffing, and equipment) for surgical specific services (SSS). A SSS may be specific clinical disciplines in the medical staff structure or the activities of surgeons (i.e., individuals or groups) who use the hospital's perioperative services and thus require organized staffing. Block scheduling can minimize variability in perioperative care as well as the scheduled resources (Kanich & Byrd, 1996). Unfortunately, perioperative block schedules are often built around surgeon or clinic schedules, seniority, or other preferences outside of the perioperative environment (Peters & Blasco, 2004). With respect to the IT

Impact Map in Figure 1, health IT applications enabling digital transformation in perioperative scheduling can yield defensive and offensive IT impact.

Perioperative Key Performance Indicators (KPIs)

Performance measurement is essential for purposeful BPM, as information before and after intervention is an integral part of process improvement. Ackoff (1967) proposed embedding feedback as control in IS design to avoid management misinformation. Similarly, organizations define business process metrics as KPIs to monitor critical success factors (CSFs) of organizational action (Munroe & Wheeler, 1980; Rockart, 1979; Zani, 1970). Hence, the perioperative process is information intensive (Catalano & Fickenscher, 2007), partially due to perioperative complexity (Fowler et al., 2008).

Perioperative KPIs reflect complex, dynamic, and nested operational, tactical, and strategic relationships. For example, perioperative schedules are linear, being tightly coupled to individual operating rooms (ORs), patients, and surgeons. When preoperative tasks are incomplete, surgical supplies not readily available, or surgeon unavailability, the scheduled case (e.g., patient's surgery) is delayed as well as the subsequent scheduled patients with the particular OR suite or surgeon. Operational and tactical KPIs in perioperative sub-processes are numerous, but intra-operative KPIs should include: (1) monitoring the percentage of surgical cases that start on-time (OTS) or first-of-the-day surgical case on-time starts (FCOTS), (2) OR turn-around time (TAT) between cases, (3) OR utilization (UTIL), and (4) labor hours expended per patient care hour as units-of-service (UOS), (Herzer et al., 2008; Kanich & Byrd, 1996; Wright et al., 2010). Tarantino (2003) notes how OR TAT and a flexible work environment are CSFs for physician satisfaction, which in turn is a CSF for hospital margin. Poor KPIs on operational and tactical metrics (e.g., OTS, TAT, UTIL, or UOS,) affect strategic CSFs of patient safety, patient quality of care, surgeon/staff/patient satisfaction, and hospital margin (Marjamaa et al., 2008; Peters & Blasco, 2004). With respect to the IT Impact Map, KPIs are applicable to measure performance in either defensive or offensive health IT applications.

Research Method

This research investigates operational excellence through the digital transformation of a hospital's perioperative scheduling process and examines a framework to yield improved patient flow, integrated hospital IS to work flow coupling, and stakeholder satisfaction. To this end, case research is particularly appropriate (Eisenhardt, 1989; Yin, 2003). An advantage of the positivist approach (Weber, 2004) 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. With respect to the statistical methods, our study used Minitab version 18 software for analysis of variance and t-tests.

Our research site (i.e., University Hospital) is an academic medical center, licensed for 1,157 beds and located in the southeastern region of the United States. University Hospital is a Level 1 Trauma Center, with a robotics program over eight SSS as well as a Women's/Infant facility. University Hospital's recognition includes Magnet since 2002 and a Top 100 Hospital by U.S. News and World Report since 2005. Concentrating on one research site facilitated the research investigation and allowed collection of longitudinal data. This research spans activities from August 2003 through September 2018, with particular historical data since 1993. During the 181-month study, we conducted field research and collected data via multiple sources including interviews, field surveys, site observations, field notes, archival records, and document reviews.

Case Background

Perioperative Services (UHPS) is the University Hospital department designated to coordinate and manage perioperative patient care across Pre-admissions, Admissions, Surgical Preparations (PreOP), Central Sterile Supply (CSS), Intra-operative (OR and ENDO), and Post Anesthesia Care Units (PACU). The workflow through CSS reprocesses all reusable surgical instruments/devices and transports supplies to and from PreOP, OR, ENDO, and PACU areas. The following sections highlight tools, events, and outcomes that have shaped UHPS' BPM approach.

CSIS Implementation

UHPS replaced its prior CSIS of 10 years in August 2003. The new CSIS supports OLAP tools, a proprietary structured query language, and both operational and managerial data stores (i.e., an operational database and separate data mart). Flexible routing templates as surgical preference cards (SPCs) allow standardization of surgical care data (i.e., particular supplies and instruments) or SPC customization for specific surgeons, SSS, and/or procedures. Since the 2003 CSIS implementation, over 7,750 generic and custom SPC configurations facilitate the SSS represented in Table-1. Similarly, the CSIS data mart serves as the central repository for perioperative process data used to support improvement initiatives as well as report KPIs via a business intelligence layer for data visualization.

University Hospital opened a new diagnostic and surgical facility (i.e., North Pavilion) in November 2004. The facility expanded UHPS' OR capacity by 33%, providing state-of-the-art OR suites with surgical specific and standardized equipment. In six weeks, a scheduling KPI reflected chaos. Surgical OTS plunged to 18% during December 2004. In the hospital industry, having 82% of surgeries experience delays and risk patient care or safety is unacceptable.

Surgical Specialty Service (SSS)	SPCs
BURN – Trauma burns	26
CARDIO –Cardiovascular & Thoracic	946
ENT – Ear, Nose, & Throat	1,030
GI – Gastro-intestinal	460
GYN – Obstetrics, gynecology	611
NEURO – Neurological	763
ORAL - Oral Maxil Facial	236
ORTHO – Orthopedic, joint/device	1,208
PLAS – Plastic surgery	681
SURG ONC – Surgical oncology	329
TX – Transplants (liver, renal)	194
TRAUMA – Trauma, MASH	203
URO – Urology	533
VASCULAR – arteries & blood vessels	558

Table 1 – Current SSSs and CSIS SPCs

Perioperative Improvement

In January 2005, UHPS expressed concerns before c-level, nursing, and physician representatives. The meeting yielded a hybrid matrix-style management structure and governance in the formation of a multidisciplinary executive team, empowered to evoke change. The executive team consisted of perioperative stakeholders (e.g., surgeons, anesthesiologists, nurses, and UHPS), chartered to focus on patient care and safety, attack difficult questions, and remove inefficiencies. No issue was off-limits. The resulting CPI effort addressed the perioperative crisis via numerous task forces employing data-driven evaluation of specific opportunities, which founded UHPS' current BPM approach (Ryan, Doster, Daily, & Lewis, 2014; 2016).

UHPS focuses BPM on data-driven analysis of KPIs at strategic, tactical, and operational levels via balanced scorecards and dashboards, aligned to hospital strategy (Ryan et al., 2014). To this end, numerous BPM efforts have targeted multiple perioperative sub-processes to improve patient workflow (Ryan et al., 2016). Table 2 is a listing of perioperative improvements by sub-process. The BPM efforts leveraged specific health IT applications to improve perioperative capabilities, beginning with the initial perioperative heuristic scheduling improvement.

Since 2005, UHPS has expanded its management beyond the initial general (GENOR) and cardio-vascular (CVOR) ORs within the North Pavilion campus to other campuses of the University Hospital Health System (UHHS) including OR suites at the Highland campus (HHOR) and Endoscopy (ENDO) labs at the TK Clinic campus. UHPS also developed a preoperative assessment, consultation, and treatment (PACT) clinic to manage all PreOP patient flow into UHPS. The PACT Clinic exists virtually in the CSIS, so the TK Clinic and Highland campus allocated physical space for patient evaluations. Since the implementation of perioperative heuristic scheduling, UHHS has experienced a 16.5% increase in surgical cases since 2007 with 59% of the average case volume being in-patient and 41% being out-patient. Emergency surgeries account for 5.3% of the average case volume. Surgical case volume during FY2018 was 44, 286 cases over the 58 ORs and 11 endoscopy labs.

Sub-process	Perioperative Improvement	Year
All	Implemented the current CSIS	2003
All	Relocated CSS and ORs	2004
All	*Governance change--initiated CPI*	*2005*
All	***Initiated OR heuristic scheduling***	***2006***
All	Addressed hospital-wide patient flow (EMR, patient tracking, CPoE, etc.)	2007
All	Established KPI reporting (strategic, tactical, and operational)	2008
All	AMC21 Balanced Scorecards	2010
PreOP	Developed PACT Clinic	2011
OR	RFID phased implementation	2012
CSS & OR	Redesigned supply workflow (CSS-to-OR-to-CSS)	2013
All	Unit-of-service CSIS charge via EMRs	2014
CSS & OR	Instrument reprocessing & tracking (CSS-to-OR-to-CSS)	2015
All	Real-time perioperative KPIs & dashboards	2016
All	Automated EMR Reconciliation	2017

Table 2 –CPI or BPR by Sub-process

Patient Flow and Integrated Hospital IS

UHHS patient admissions are either medical or surgical. Surgical patient admissions occur via: 1) diagnostic office visits to physicians within the TK Clinic, 2) non-UHHS physician referrals to the PACT clinic, or 3) patients seeking treatment through the Emergency Department. All surgical patients receive a PACT Clinic evaluation prior to their scheduled procedures.

Figure-2 depicts the integrated hospital IS used to facilitate and document perioperative patient care across UHHS. All UHHS patients' (i.e., in-patient or outpatient) medical records, admissions, diagnostics, clinical data and observations, as well as discharges occur via the same integrated hospital IS.

IS depicted in Figure-2 are integrated with either bi-directional or uni-directional data exchange. The seven IS modules clustered around the CSIS directly support and extend the CSIS suite, where the Clinical Charting IS houses computerized provider order entry (i.e., CPOE) and electronic medical records (i.e., EMRs). The HIPAA (i.e., Health Insurance Portability and Accountability Act of 1996) compliant Web Services and biomedical device interface bus (i.e., BDIB) integrate ancillary IS, clinical data sensors, and bio-medical equipment. The institutional intranet serves as a single entry secured portal to extend each IS according to particular user-IS rights and privileges negotiated via user authentication.

Observed Effects

Surgical UHHS patients move through the perioperative workflows via events: (1) A clinic visit resulting in diagnosis for surgical case scheduling, (2) PACT Clinic evaluation, (3) day of surgery admission, (4) PRE-OP, (5) intra-operative procedure, (6) PACU, (7) PACU Phase-II, and (8) discharge or movement to a medical bed. The initial CPI efforts during 2005 identified that traditional block scheduling (e.g., assigning a 7 a.m. to 4:30 p.m. block of time for a particular OR suite to a particular SSS) yielded inefficiency and failed to reflect actual SSS patient volume. SSS with low patient volume had surplus ORs assigned, while SSS with high patient volume had deficit ORs assigned, yielding further delays in perioperative scheduling. The inefficient OR utilization associated with block scheduling also concealed other perioperative sub-process inefficiencies upstream and downstream of intra-operative procedures. The following subsections explain the BPM effort to establish modified block heuristic scheduling, perioperative scheduling digital transformation, and gains toward operational excellence.

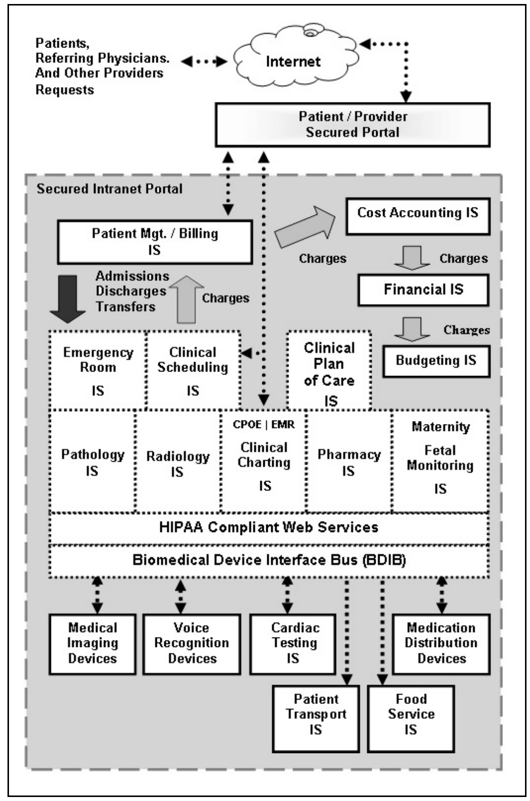


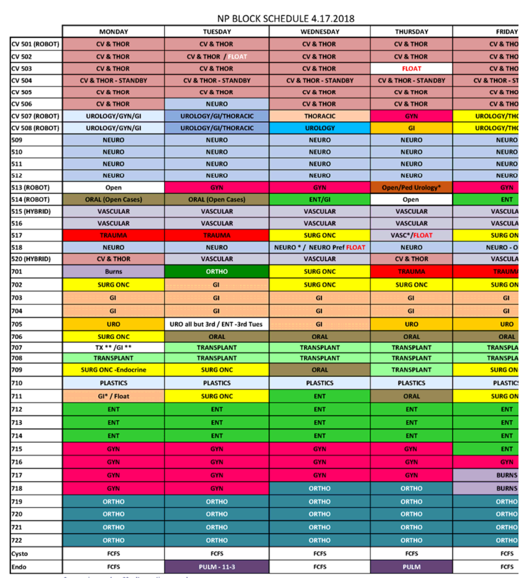
Figure 2 - UHHS Integrated IS

Modified Block Heuristic Scheduling

The actual OR hours used by SSS patients (i.e. SSS cases) stored in the CSIS data mart were analyzed against OR block assignment hours allocated to each SSS (i.e., Table 1). The data analysis identified BPR opportunity within the perioperative scheduling process. Straight SSS block scheduling was discontinued, excluding one GENOR room retained specifically for trauma patients to meet Level I Trauma Center requirements. Given physician satisfaction is linked to SSS specific OR block scheduling (Peters & Blasco, 2004), initial block assignments allow for outside-of-a-week planning. Since 2006, quarterly modifications to SSS block assignments yield SSS block assignments of OR time based on SSS case (i.e., patient) volume. Similar to marketing segmentation among demographic groups, SSS specific OR time used from historical data establish predictable average SSS case volume. Figure 3 visualizes SSS block time allocations for North Pavilion campus ORs for Q3 2018.

SSS time allotments are the basis for scheduling rules. Quarterly reviews yield routine SSS block time allotment adjustments. SSSs who overstate their case volume needs are penalized when OR time allocations go unused. When a SSS fails to consecutively utilize 65% of a daily OR block during a review period, the unused OR block is available to be reallocated to another SSS. SSSs who consecutively utilize more than 80% of an OR's daily block receive the reallocated time. When a SSS releases a specific OR time allotment within 48 hours of day of surgery (i.e. DOS), that SSS's excess release is excluded from the SSS utilization. SSSs with wide variability in patient scheduling receive consideration and a reduction in early release OR blocks.

Specific SSS block release rules also allow surgeons within a particular SSS to schedule OR time, not in their specific ORs, 72-hours out from DOS. A surgeon in any SSS can schedule OR time in any available OR 36-hours out from DOS. Additional heuristic rules define specific SSS preferences, robotic rooms, hybrid rooms, specific UHHS campus OR preferences, cystoscopic and endoscopic preferences, staff allocations, and length of OR availability per day. For example, robotic room SSS allocations are releasable 14 days from DOS, due in part to the high demand on the limited resource (i.e., five DaVinci robots). As new


NP BLOCK SCHEDULE 4.17.2018

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
CV 501 (ROBOT)	CV & THOR	CV & THOR	CV & THOR	CV & THOR	CV & THO
CV 502	CV & THOR	CV & THOR / FLOAT	CV & THOR	CV & THOR	CV & THO
CV 503	CV & THOR	CV & THOR	CV & THOR	FLOAT	CV & THO
CV 504	CV & THOR - STANDBY	CV & THOR - STANDBY	CV & THOR - STANDBY	CV & THOR - STANDBY	CV & THOR - ST
CV 505	CV & THOR	CV & THOR	CV & THOR	CV & THOR	CV & THO
CV 506	CV & THOR	NEURO	CV & THOR	CV & THOR	CV & THO
CV 507 (ROBOT)	UROLOGY/GYN/GI	UROLOGY/GI/THORACIC	THORACIC	GYN	UROLOGY/THO
CV 508 (ROBOT)	UROLOGY/GYN/GI	UROLOGY/GI/THORACIC	UROLOGY	GI	UROLOGY/THO
509	NEURO	NEURO	NEURO	NEURO	NEURO
510	NEURO	NEURO	NEURO	NEURO	NEURO
511	NEURO	NEURO	NEURO	NEURO	NEURO
512	NEURO	NEURO	NEURO	NEURO	NEURO
513 (ROBOT)	Open	GYN	GYN	Open/Ped Urology*	GYN
514 (ROBOT)	ORAL (Open Cases)	ORAL (Open Cases)	ENT/GI	Open	ENT
515 (HYBRID)	VASCULAR	VASCULAR	VASCULAR	VASCULAR	VASCULA
516	VASCULAR	VASCULAR	VASCULAR	VASCULAR	VASCULA
517	TRAUMA	TRAUMA	SURG ONC	VASC*/FLOAT	SURG ON
518	NEURO	NEURO	NEURO * / NEURO Pref FLOAT	NEURO	NEURO - O
520 (HYBRID)	CV & THOR	VASCULAR	VASCULAR	CV & THOR	VASCULA
701	Burns	ORTHO	SURG ONC	TRAUMA	TRAUMA
702	SURG ONC	GI	SURG ONC	SURG ONC	SURG ON
703	GI	GI	GI	GI	GI
704	GI	GI	GI	GI	GI
705	URO	URO all but 3rd / ENT -3rd Tues	GI	URO	URO
706	SURG ONC	ORAL	ORAL	ORAL	ORAL
707	TX ** /GI **	TRANSPLANT	TRANSPLANT	TRANSPLANT	TRANSPLA
708	TRANSPLANT	TRANSPLANT	TRANSPLANT	TRANSPLANT	TRANSPLA
709	SURG ONC -Endocrine	SURG ONC	ORAL	TRANSPLANT	SURG ON
710	PLASTICS	PLASTICS	PLASTICS	PLASTICS	PLASTICS
711	GI* / Float	SURG ONC	ENT	ORAL	SURG ON
712	ENT	ENT	ENT	ENT	ENT
713	ENT	ENT	ENT	ENT	ENT
714	ENT	ENT	ENT	ENT	ENT
715	GYN	GYN	GYN	GYN	ENT
716	GYN	GYN	GYN	GYN	GYN
717	GYN	GYN	GYN	GYN	BURNS
718	GYN	GYN	ORTHO	ORTHO	BURNS
719	ORTHO	ORTHO	ORTHO	ORTHO	ORTHO
720	ORTHO	ORTHO	ORTHO	ORTHO	ORTHO
721	ORTHO	ORTHO	ORTHO	ORTHO	ORTHO
722	ORTHO	ORTHO	ORTHO	ORTHO	ORTHO
Cysto	FCFS	FCFS	FCFS	FCFS	FCFS
Endo	FCFS	PULM - 11-3	FCFS	PULM	FCFS

* morning only ** alternating weeks

Figure 3 – NP Modified Block Schedule

complexities evolve in the perioperative scheduling process, heuristic rules are formulated, tested, and added to the CSIS scheduling rules to manage the complexity.

Digital Transformation

In 2007, UHHS extended the CSIS integration across University Hospital for integrated data and networked perioperative process access (scheduling, patient flow, tracking, EMRs, CPOE, etc.). Surgeons, surgeons' staff, or SSS staff schedule surgical cases online from their office via the UHHS integrated IS from Figure 2, with synchronous scheduling of PACT Clinic evaluation appointments. Via the extended CSIS, the surgeon or staff per surgeon's order creates a surgical case for a patient's procedure using a specific SPC (i.e., Table 1). Released OR suites and openings in the SSS schedule are displayed for selection as depicted in Figure-4. Posting the surgical case into the schedule queue creates an ambulatory EMR with associated orders for the surgical procedure (i.e. Clinical Plans of Care IS). Via the Clinical Charting IS (i.e. CPOE), the surgeon or staff can add standardized or customized orders to the EMR from available template options in the Clinical Plan of Care IS. Figure-5 depicts the categories of CPOE orders available via the Clinical Plan of Care IS. The ambulatory EMR will also accept pertinent external records (i.e. outside UHHS medical records) as attachments.

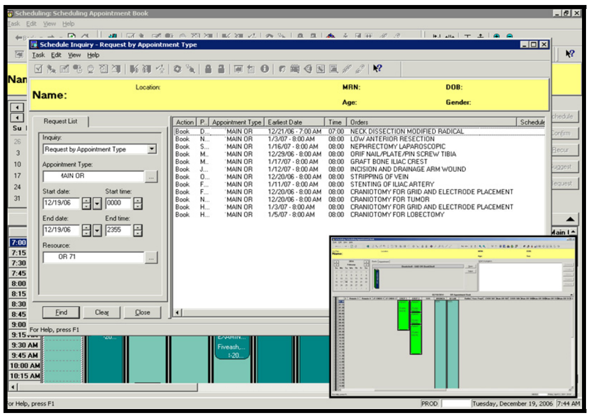


Figure 4 - CSIS Case Scheduling Screenshot

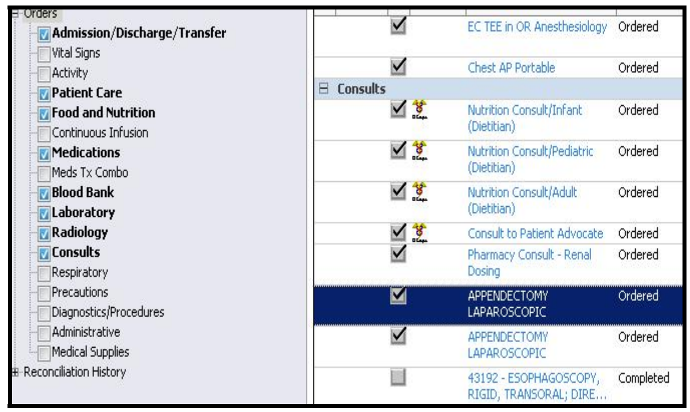


Figure 5 - CPOE Order Options Screenshot

Operational Excellence

Figure 6 illustrates OTS gains made via BPM efforts listed in Table 2. The structural, process, and cultural changes achieved in UHPS intra-operative sub-process over FY05 and FY06 allowed UHHS to extend the CSIS across University Hospital in early 2007. The extended CSIS quickened the digital transformation of perioperative scheduling, to broaden perioperative data collection capabilities and position BPM efforts of CPI and BPR toward hospital-wide patient flow. Effects of improved perioperative scheduling yielded the process improvement efforts identified from Table 2 and improved operational capabilities.

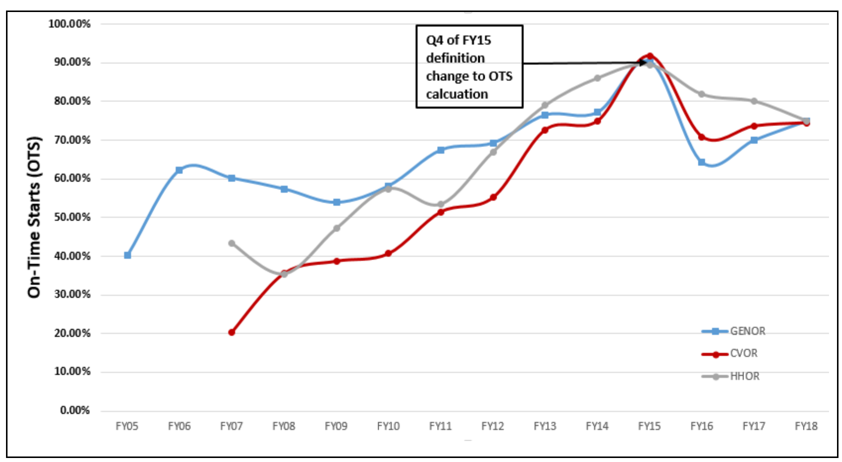


Figure 6 – OTS KPI Metrics from FY05 to FY18

The state of UHPS in early 2005 prohibited streamlining hospital-wide patient flow without first streamlining intra-operative patient flow. Likewise, the modified heuristic block scheduling improved perioperative process scheduling and the digital transformation yielded a tighter coupling to actual surgical patient demand (e.g., cases). Table 3 illustrates this improvement by SSS, listing the average days between scheduling a surgical procedure and the DOS for FY05, FY07, and FY18. FY05 is prior to the scheduling improvement implementation. FY07 is the first full year of implementation. FY18 is the most recent year reflecting the evolved heuristic scheduling rules. The modified heuristic block schedule with release rules lowered average days for many SSSs (i.e., 8 of 14, or 57% for FY07; 7 of 14, or 50% for FY18). SSSs using robotic surgery as the preferred standard of care (e.g., SURG ONC, THORACIC, TX, URO, VASCULAR) yielded higher average days due to resource limitations. Moreover, the FY07 and FY18 average days are not statistically different from the FY05 average days, since both 99% confidence intervals overlap with FY05. On average, patients experience about 7 days between surgical procedure diagnosis and DOS. North Pavilion patient volume increased by 54% between FY05 and FY18 while the modified heuristic block scheduling explained more variation among SSSs. To this end, the digital transformation observed effects represented in Figure 6 and Table 3 depict UHPS' perioperative scheduling improvement.

SSS	FY05 Days	FY07 Days	FY18 Days
BURN	2.929	1.964	0.559
CARDIO	4.570	0.926	3.446
ENT	12.128	11.959	3.770
GI	8.615	10.784	3.360
GYN	12.051	15.123	9.660
NEURO	2.525	1.840	4.080
ORAL	5.746	4.138	7.704
ORTHO	6.549	3.599	4.034
PLAS	11.375	9.235	13.280
SURG ONC	11,784	9.516	21.611
TX	3.285	5.964	10.491
TRAUMA	0.955	0.652	0.878
URO	13.337	18.604	28.04
VASC	2.636	4.540	5.659
Avg. Days	7.098	6.655	7.243
99% CI	(6.856, 7.341)	(6.447, 6.862)	(7.002, 7.482)
Patients	14,415	20,862	22,255
R^2(adj)	12.82%	20.49%	22.31%

Table 3 –North Pavilion Average Days to DOS

ANALYSIS AND DISCUSSION

Previous sections on case background and observed effects demonstrate the digital transformation of the UHHS perioperative scheduling process where UHPS' CSIS integration and BPM efforts support a tight coupling between patient care, perioperative workflow (i.e., patient flow), and the integrated hospital IS. Moreover, the CSIS scheduling information yield aggregated surgical case (i.e., patient) data leveraged as KPI metrics to further understand, manage, and improve perioperative workflow, resources, and performance (Ryan et al., 2016). The following sub-sections discuss digital maturity as well as defensive for offensive IT impact with respect to the literature, case, and observed effects.

Digital maturity

Organizational digital maturity is a CSF for digital transformation that reflects strategy, culture, and talent (Kane et al., 2015). For strategy, digital transformation requires reconfiguring processes to exploit health IT abilities and information through digital technologies integrated across people, processes and functions. Increasing health IT impact on core capabilities (e.g., Figure 1) moves an organization from incremental improvement (i.e., CPI) to business process redesign (BPR). To this end, UHPS uses CSIS data to improve perioperative sub-processes via business analytics, OLAP, and data mining (e.g., see Table 2). Likewise, having high IT impact on core strategy and increasing IT impact on core capabilities moves an organization from emerging opportunity to business transformation. The modified heuristic block schedule are examples of implementing health IT innovatively. Organizational culture and employee talent are visible via the BPM efforts during FY2005 and FY2006, as well as the perioperative improvements listed in Table 2. UHHS also uses KPI targets and BPM efforts as annual goal objectives for personnel and SSSs to meet in the strategic plan (Ryan et al., 2016).

In a digital transformation strategy, an operational backbone and a digital services platform are essential enterprise architecture assets (Sebastian et al., 2017) to execute internal operational excellence (i.e., defensive IT impact) and external customer experience (i.e., offensive IT impact). The CSIS is the UHHS operational backbone providing a single source of reconciled perioperative data. U.S. hospitals eligible for CMSEHRIP (e.g., 95%) have a similar operational backbone (ONC, 2017). The HIPPA compliant Web services and BMDIB within the UHHS integrated IS (e.g., Figure-2) constitute a digital services platform to facilitate rapid development and integration of digital innovations.

Defensive for offensive IT impact

The BPM efforts applied to perioperative scheduling has positioned UHHS to achieve a level of operational excellence, as evidenced by its BPM efforts, improved patient flow, and OTS KPI metrics. In turn, operational excellence positions UHHS to pursue external customer experience centered on enhanced collaboration between perioperative stakeholders (e.g., healthcare providers, patients, and their families).

With respect to the IT Impact Map (i.e., see Figure 1), measured efficiencies in CPI and BPR of perioperative scheduling moved UHHS from Support to Factory Modes and yielded defensive IT impact. Innovatively applying measured efficiencies through digital transformation of perioperative scheduling improved patient experience and patient satisfaction that moved UHHS into Turnaround Mode and yielded offensive IT impact. Likewise, using patient experience KPIs as strategic goals to foster provider-patient collaboration has moved UHHS into Strategic Mode and yielded offensive IT impact (Ryan et al., 2014; 2016; 2017).

CONTRIBUTIONS AND LIMITATIONS

This paper fills a healthcare literature gap noted by Agarwal et al. (2010) for leveraging health IT applications through the integration and use of modified heuristic block rules during the digital transformation of perioperative scheduling. Furthermore, this study contributed to the healthcare IT literature by examining operational excellence through perioperative digital transformation and the lens of IT impact to prescribe an a priori framework to foster the reoccurrence. Moreover, empowered teams, integrated IS coupled to workflow, leveraged health IT, and a holistic BPM approach supported the observed effects. This case study demonstrated BPM efforts of CPI and BPR as adaptable practices when leveraging health IT in the hospital environment. Likewise, the BPM efforts within the observed effects demonstrated communication, innovation, as well as individual and collective organizational learning.

This study has limitations. One limitation to the study's generalization to other hospitals would be conditional as to whether the hospital's IS architecture is equipped with a digital services platform required to facilitate implementation and integration of digital innovation opportunities. The study is also limited to a single case, where future research should broaden focus as well as address other limitations inadvertently overlooked.

Overall, the study results were exploratory and need further confirmation. The case examples can serve as momentum for perioperative methodology, complexity comprehension, and improvement extension. Researchers may choose to further or expand the investigation, while practitioners may apply the practices within their perioperative environment.

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