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11-2019

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### WMU ScholarWorks Citation

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## Business Process Redesign in the Perioperative Process: A Case Perspective for Digital Transformation

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**Abstract:** This case study investigates business process redesign within the perioperative process as a method to achieve digital transformation. Specific perioperative sub-processes are targeted for re-design and digitalization, which yield improvement. Based on a 184-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 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 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.

## INTRODUCTION

Within the hospital environment, the perioperative process 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). To these end-state goals, the perioperative process provides surgical care for inpatients and outpatients during pre-operative, intra-operative, and immediate post-operative periods. Consequently, perioperative workflow tightly couples patient flow, patient safety, patient quality of care, and hospital stakeholders' satisfaction (i.e. patient, physician/surgeon, nurse, perioperative staff, and hospital administration). Accordingly, the perioperative sub-processes (e.g. pre-assessment, pre-operative, intra-operative, and immediate post-operative) are sequential where each activity sequence paces the efficiency and effectiveness of subsequent activities. Furthermore, perioperative sub-processes require continuous parallel replenishment of centralized sterile supplies along with the removal and sanitation of soiled materials, instruments, and devices. Hence, implementing improvements or digitalization is both a challenge and an opportunity for hospital stakeholders, who often have a variety of opinions and perceptions as to where efforts should focus.

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 business process redesign prior to health IT integration and use, as the perioperative digitalization will have little impact on performance if not well integrated into daily healthcare providers' workflows (Agarwal, et al., 2010; Wears & Berg, 2005).

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 offer perioperative quality, efficiency, and effectiveness improvement to ultimately yield hospital financial performance.

This research investigates complexity and change dynamics observed during a hospital's digital transformation of perioperative sub-processes. 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 intra-operative, pre-operative, and post-operative digital transformation prescribed opportunity for measured improvement. Specifically, this study investigates the research question as to how business process redesign within the digital transformation of a hospital's perioperative sub-processes can yield operational excellence and enable improved patient flow, integrated hospital IS to workflow coupling, and stakeholder satisfaction.

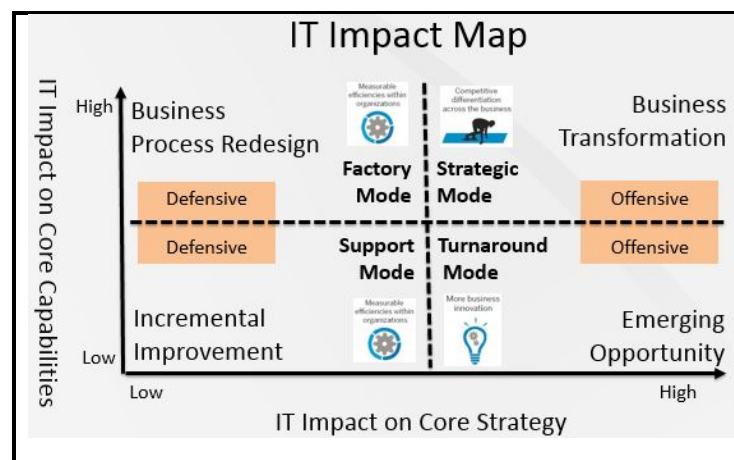
The following sections review previous literature with respect to digital transformation, business process redesign (BPR), business process management (BPM), and key performance indicators (KPIs). Following the literature review, we present our methodology, case study background, observed effects, and discussion. By identifying a holistic 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

A digital business strategy identifies how an organization aligns IT to create a fusion between IT strategy and business strategy (Bharadway et al., 2013). Likewise, the digital business strategy distinguishes how healthcare providers leverage healthcare IT capabilities and differentiates the success level of digital transformation. To this end, Applegate, McFarland, and Austin (2009) noted how organizations can view their core capabilities and core strategy through an IT lens to delineate IT impact. The resulting IT Impact Map, illustrated in Figure 1, depicts the four quadrants and modes an organization can exhibit by varying IT impact levels on core capabilities versus core strategy.

### Digital Transformation

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). Digital transformation is similar to the IT Impact Map's representation of defensive and offensive IT in Figure 1. Digital transformation is evolutionary and leverages



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

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).

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 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 Redesign (BPR)**

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: (1) the incremental improvement addresses symptoms versus causes; (2) the improvement effort is sustainable year after year; or (3) 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., Figure 1) offers the most radical change when compared to CPI. IT impact capabilities from BPR do not digitally replicate manual processes. BPR offers radical redesign when compared to CPI, with greater reward of upwards to 1,000 percent, while assuming higher risk, durations, costs, and difficulty (Tenner & DeToro, 1997). BPR is rethinking and redesigning to achieve dramatic improvements in performance (e.g. cost, quality, service, and speed) by questioning activity relevance and reinventing innovative ways to accomplish 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.

### **Business Process Management (BPM)**

Incremental improvement and BPR are tenants of BPM. This study uses the BPM definition provided by Jeston and Nelis (2008, p. 10) as "the achievement of an organization's objectives through the improvement, management, and control of essential 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 business process performance improvement that meets organizational objectives. To this end, BPM embraces the concepts of incremental improvement and BPR aligned to hospital strategy. Specifically, this study uses BPM techniques to measure improvement.

Business analytics is the body of knowledge identified with technology solutions that incorporate performance management, definition and delivery of business metrics, as well as data visualization and data mining (Turban et al., 2008). Business analytics within BPM focus on the effective use of organizational data and information to drive positive business action (Turbin et al., 2008). The effective use of business analytics demands knowledge and skills from subject matter experts and knowledge workers. Similarly, Wears and Berg (2005) concur that IS and/or IT only yield high-quality healthcare when the use patterns are tailored to knowledge workers and their environment. Therefore, BPM success has a strong dependence on contextual understanding of end-to-end core business processes (Jensen & Nelis, 2008).

## Key Performance Indicators (KPIs)

Performance measurement is essential for purposeful BPM, as information before and after the intervention is an integral part of process improvement. Early in the IT literature, Ackoff (1967) proposed embedding control feedback in IS design to avoid management misinformation. Similarly, organizations define data metrics as KPIs to monitor critical success factors (CSFs) (Munroe & Wheeler, 1980) within business processes (i.e., organizational action). The perioperative process is information intensive (Catalano & Fickenschner, 2007), due to its complexity (Fowler et al., 2008). BPM of perioperative sub-process KPIs reduce complexity and information intensity (Ryan, et al., 2017).

Operational and tactical KPIs in perioperative sub-processes are numerous, but intra-operative KPIs for operational excellence 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), [49, 13, 19, 29] (Herzer et al., 2008; Kanich & Byrd, 1996; Peters & Blasco, 2004; Wright et al., 2010). Customer experience KPIs should include Consumer Assessment of Healthcare Providers and Systems surveys (HCAHPS, 2017) for patient perspectives of hospital care (i.e., HCAHPS) or clinician group care (i.e., CGCAPHS), as well as employee satisfaction surveys. Tarantino (2003) noted 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, UOS, or HCAHPS) affect strategic CSFs of patient safety, patient quality of care, surgeon/staff/patient satisfaction, and hospital margin (HCAHPS, 2017; 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 healthcare IT applications.

## RESEARCH METHOD

This research investigates the digital transformation of a hospital's perioperative sub-processes and questions how business process redesign can yield operational excellence and enable improved patient flow, integrated hospital IS to workflow coupling, and stakeholder satisfaction. To this end, case research is particularly appropriate (Eisenhardt, 1989; Yin, 2003). Another 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.

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 surgical service specialties (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 December 2018, with particular historical data since 1993. During the 184-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 and Endoscopy (OR), and Post Anesthesia Care Units (PACU). The workflow through CSS reprocesses all reusable surgical instruments/devices and transports supplies to and from PreOP, OR, and PACU areas.

UHPS replaced its prior CSIS of 10 years in 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 and/or procedures.

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

**Table 1: University Hospital SSS**

Since the new CSIS implementation, over 7,750 generic and custom SPC configurations facilitate the surgical specialty services (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. The following sections highlight tools, events, and outcomes that have shaped UHPS' BPM approach.

### Perioperative Process Improvement

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

In January 2005, UHPS expressed concerns before a quickly convened meeting of 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.

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. Table 2 details a complete listing and timeline of UHPS' perioperative improvements.

Since 2005, UHPS has expanded its management beyond the initial general (GENOR) and cardio-vascular (CVOR) ORs of the North Pavilion campus. UHPS management includes 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 HHOR allocated physical space for patient evaluations. Overall, UHHS has experienced a 10.9% 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 44,287 cases over the 58 ORs and 11 endoscopy labs.

Area	Improvement	Year
All	Implemented the current CSIS	2003
All	Relocated CSS and ORs	2004
<u>All</u>	<u>Governance change--initiated</u> <u>CPI</u>	<u>2005</u>
➔ OR	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
➔ PACU	Phase II and ICU Overnight EMRs	2014
All	Automated charges 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: Perioperative Improvements

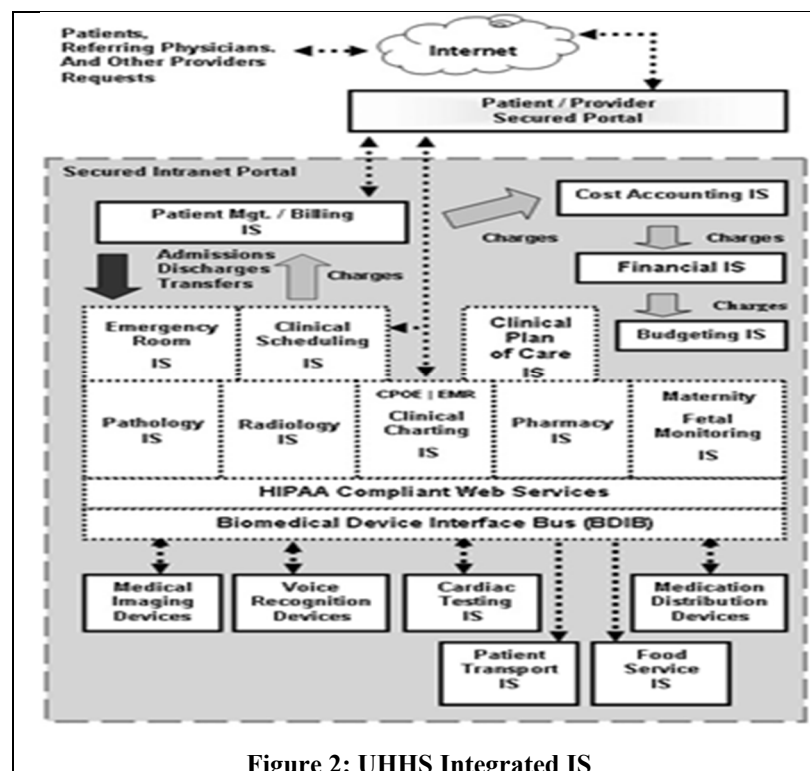


Figure 2: UHHS Integrated IS

## Patient Flow and Integrated IS

Surgical patient admissions occur via the PACT Clinic, with referrals via three venues: 1) diagnostic office visits to physicians within the TK Clinic, 2) non-UHHS physicians, or 3) the Emergency Department. Figure 2 depicts the integrated hospital IS used to facilitate and document perioperative patient care across UHHS. UHHS patients' (i.e., in-patient or outpatient) medical records, admissions, diagnostics, clinical data and observations, as well as discharges are processed and recorded via the same integrated hospital IS. All IS depicted in Figure 2 are integrated with either uni-directional constraints for limited data exchange or bi-directional data exchange. The seven IS clustered around the CSIS are modules that directly support and extend the CSIS suite, where the Clinical Charting IS houses CPoE and EMRs. The HIPPA compliant Web services and BMDIB (i.e., biomedical device interface bus) integrate ancillary IS, clinical data sensors, and bio-medical equipment. The institutional intranet serves as single entry portal access to extend each IS according to particular user-IS rights and privileges negotiated via user authentication.

## OBSERVED EFFECTS

Surgical UHHS patients move through perioperative workflows via events: (1) A clinic visit resulting in a surgery diagnosis, (2) surgical patient scheduling, (3) PACT Clinic evaluation, (4) day of surgery admission, (5) PreOP, (6) intra-operative procedure, (7) PACU, (8) PACU Phase-II, and (9) discharge or movement to a medical bed. However, the current perioperative workflow and resulting patient flow are the product of BPM efforts, where numerous BPM task forces have targeted multiple perioperative sub-processes for improved patient workflow.

All of the BPM efforts in Table 2 leveraged specific defensive healthcare IT applications (i.e., Figure 1) to improve perioperative capabilities. The four BPR examples highlighted in Table 2 and discussed in this study are: (1) OR scheduling; (2) hospital-wide electronic medical record (EMRs) integration; (3) preoperative patient evaluations; and (4) PACU EMR documentation. The following subsections explain the BPM efforts to redesign these sub-processes and workflows to enable digital transformation and gains toward operational excellence.

### OR Scheduling

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 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 in the OR scheduling process. Straight SSS specific OR block schedules were discontinued, excluding one OR retained to meet Level I Trauma Center requirements. As physician satisfaction is linked to SSS specific OR

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 <sup>2</sup> (adj)	12.82%	20.49%	22.31%

**Table 3: North Pavilion Average Days to DOS**

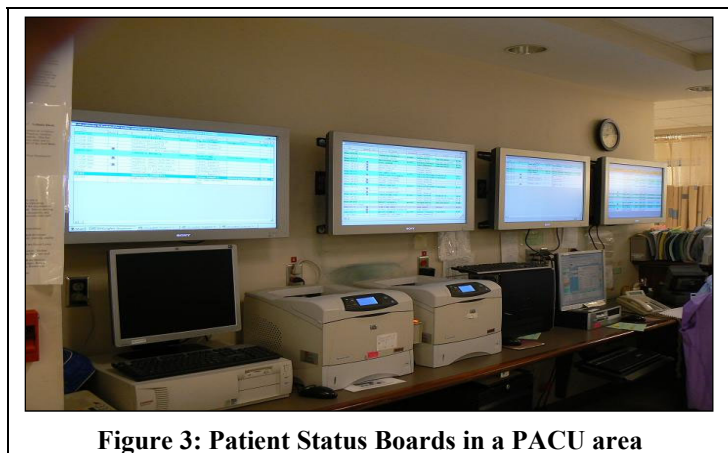


block scheduling (Peters & Blasco, 2004), initial block assignments allow for outside-of-a-week planning. Since 2006, quarterly modifications to SSS block assignments yield SSS OR time blocks based on SSS case (i.e., patient) volume. Similar to marketing segmentation among demographic groups, SSS specific OR time used from historical data establish predictable average SSS case volume. 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 day of surgery (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, cystoscopy and endoscopy preferences, staff allocations, and length of OR availability per day.

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. Although the average days between the three years are not statistically different, as indicated by the overlapping 99% CIs for each year, note the volume of patient flow increase (e.g., 54%) between FY05 and FY18. Likewise, the scheduling rules in FY18 explained more (e.g., 74%) of the scheduling variation (i.e.,  $R^2_{adj}$ ) than FY05.

### Hospital-wide EMR Integration

The structural, process, procedural, and cultural changes achieved in UHPS over FY05 and FY06 allowed the executive committee to move forward in early 2007 to extend the clinical scheduling IS across UHHS and address hospital-wide patient flow and documentation. The new areas integrating with the CSIS were Admissions, PreOP, PACU, CSS, and all other ancillary services. The hospital-wide EMR integration encompassed 11 task forces covering surgeon's orders, clinical documentation, electronic medical records, pharmacy, physician workflow, critical care, knowledge and content, technical metrics, communications, and testing/training/transition.



**Figure 3: Patient Status Boards in a PACU area**

The project's goal was improvement of patient flow, documentation, and satisfaction through extended CSIS functionality, IT capabilities, and patient tracking technology. The enterprise application integration process redesign efforts yielded the additional IS modules clustered around the CSIS in Figure 2. The most visible interface into the dissemination of perioperative process information across Admissions, PreOp, intra-operative, and PACU were electronic patient status boards. The deployed boards were in each functional perioperative area, visitor waiting area, and the patient information was HIPAA compliant. Figure 3 depicts the patient status boards in a PACU area at the North Pavilion campus.

## Pre-operative Patient Evaluations

Figure 4 depicts the annual averaged on-time start (OTS) KPIs for GENORs, CVORs, and HHORs from FY05 to FY18. The hospital-wide EMR integration in 2007 omitted parts of required PreOP evaluation documentation (e.g., external medical records, PreOP assessment, as well as medical, surgical, and medication history). The GENOR OTS KPI average for FY10 was 55.8% versus a target of 70%. Upon closer analysis of the surgical case delays, 17.5% were preventable. CSIS data reflected incomplete patient information delays for over one out of six surgical cases. As a result, UHPS launched a PACT Clinic task force to redesign preoperative patient evaluations. Task force members visited four leading academic medical centers in the United States, as well as the two internal University Hospital sites, to gather a transparent and bottom-up view of different perspectives to preoperative evaluation processes. The external sites were located in: (1) Baltimore, MD; (2) Boston, MA; (3) Rochester, MN; and (4) Cleveland, OH.

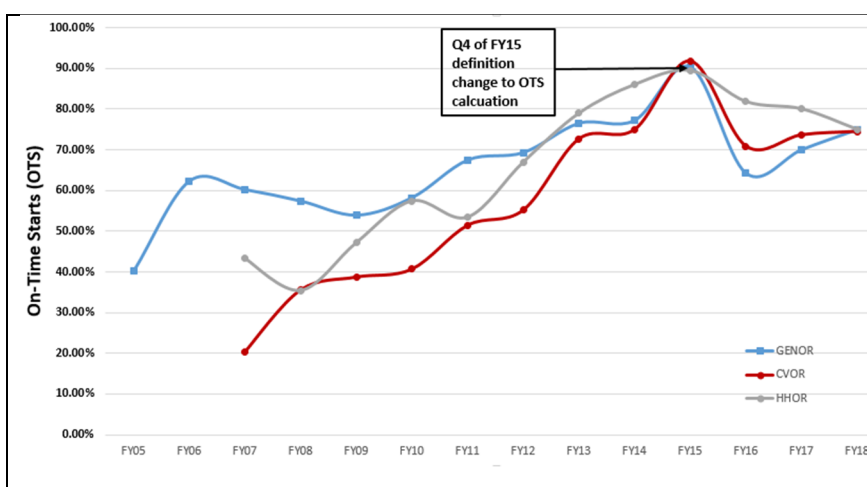


Figure 4: OTS KPI Metrics from FY05 to FY18

Essential elements of the redesign required EMR inclusion of all pertinent external records with the initial UHHS referral and the PreOP assessment appointment is made simultaneously with the initial surgeon appointment. Patient screening and standardized co-morbidity risk stratification occurs by telephone, the Internet, or by the surgical clinic making the referral. The best practices identified during the site visits afforded University Hospital the opportunity to redesign their preoperative patient evaluation into a preoperative assessment, consultation, and treatment (PACT) clinic. A “clinic without walls” in that the PACT clinic exists only within the CSIS and evaluations can occur anywhere within UHHS. Since the PACT Clinic implementation in FY12, the OTS KPI target of 70% on-time has been achievable as illustrated in Figure 4.

## PACU EMR Documentation

UHPS developed and configured CSIS nursing documentation as EMRs to document and manage patient care accountability across perioperative workflows. PACU nurses receive surgical patients from the OR and continue acute care per surgeon’s orders until patient recovery. As a critical care unit similar to the OR suite, the CSIS collects PACU clinical data from bio-medical equipment and monitoring sensors (i.e., BMDIB in Figure 2). Within the PACU area, nurses have four EMR types to document patient care and events. The PACU Nursing Record EMR documents acute care delivery. The ICU/After Hours PACU Overflow Record EMR, via the CSIS, documents acute care for patients that are over-nighting in PACU due to overflow conditions in the ICU. Both PACU acute care EMRs capture patient UOS charges as depicted in Figure-2. As surgical patients recover from anesthesia, the need for acute care lessens. Within the CSIS, a PACU Phase-II Nursing Record EMR posted to the patient’s surgical case identifies when PACU acute care ends. When surgical patients completely recover from anesthesia, the attending PACU nurse discharges the patient from Phase-II and discontinues documentation to the patient’s surgical case. Likewise, the PACU staff discharge outpatients per surgeon orders, while in-patients are transported to a hospital bed.

<b>CSIS Nursing Record EMRs</b>	<b>FY Start</b>	<b>UOS Std.</b>	<b>UOS Unit</b>
Ancillary Record - Family	2007	--	--
PreOP Nursing Assessment	2012	1.93	Time
Endo PreOP Nursing Record	2014	--	Procedure
Endo Sedation Nursing Record	2014	2.1	Time
PreOp Regional Block Nursing Record	2014	2.21	Time
CSS	2003	3.52	Load
OR Nursing Record - CVOR	2007	9.04	Time
OR Nursing Record - Cardiac Perfusion	2012	4.22	Time
OR Nursing Record - GENOR	2003	7.45	Time
OR Nursing Record - ENDO	2014	6.92	Procedure
Ancillary Record – Room Cleanup	2005	--	Time
► PACU Nursing Record	2010	2.71	Time
► ICU/After Hours PACU Overflow Record	2014	2.71	Time
► PACU Phase-II Nursing Record	2014	1.93	Time

**Table 4: CSIS Nursing Documentation and UOS**

CSIS nursing EMRs differentiate patient care for charge billing and resource allocations. Within PACU, the Phase-II and ICU nursing records also facilitate PACU workflow balancing and bed/resource utilization. Within PreOP and PACU, a finite number of acute care beds are valued resources, when compared to ambulatory care beds. The PACU Phase II Nursing Record allows ambulatory nursing documentation via the CSIS in any University Hospital ambulatory bed. Hence, PACU Phase II patients are transferable to PreOP or floor beds when PACU beds are in critical supply. Moreover, the ICU Overflow EMR identifies ICU capacity issues and avoids unplanned ICU discharges (Utzolino et al., 2010). PACU Phase-II EMRs document ambulatory care that has lower patient UOS charges and allows any UHHS hospital bed having ambulatory patient care to become PACU Phase-II. Hence, PACU Phase-II Nursing Record EMRs via the CSIS create a virtual PACU allowing more critical patients to remain in PACU acute care beds. Table 4 lists the current UHHS Nursing Record EMRs used across the perioperative sub-processes within the GENOR, CVOR, HHOR, and TKC labs.

## ANALYSIS AND DISCUSSION

Previous sections on case background and observed effects demonstrate the BPR opportunity during the digital transformation of the UHHS perioperative process. 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 data yield aggregated KPI metrics to further understand, manage, and improve perioperative workflow, resources, and performance. The following sub-sections discuss digital maturity, defensive for offensive IT impact, as well as UHPS digital transformation CSFs 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, patient status boards, PACT Clinic, and PACU EMRs are examples of implementing health IT innovatively. Organizational culture and employee talent are visible via the BPM

efforts and 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 OR scheduling, hospital-wide EMR integration, PreOP patient evaluations; and PACU EMRs moved UHHS from Support to Factory Modes and yielded defensive IT impact. Innovatively applying measured efficiencies gained through BPR and the digital transformation of the perioperative process adds to UHHS patient experience and patient satisfaction surveys. The enhanced customer experience moved UHHS into Turnaround Mode and yielded offensive IT impact. Likewise, using patient experience KPIs as strategic goals to foster provider-patient collaboration (Ryan et al., 2014) has moved UHHS into Strategic Mode and yielded offensive IT impact.

### **UHPS Digital Transformation CSFs**

Digital transformation offers workflow productivity via IT applications, the ability to better manage process performance via data availability and visibility, as well as the ability to meet customer experience expectations (IDG, 2018). UHHS was not seeking these particular benefits when it changed UHPS' governance in FY05, but the change evoked continuous data-driven improvement. To this end, UHPS' digital transformation has evolved over time. The following observed CSFs, summarized from the case, provide an a priori framework for UHPS' digital transformation:

- ☐ The agile, integrated CSIS as an operational backbone, with the HIPPA compliant Web services and BMDIB as a digital services platform.
- ☐ Changed governance using matrix-style management from cross-functional departments.
- ☐ CSIS implementation and EMR integration was phased to achieve proof of concept—first in intra-operative and CSS, moving later upstream to PreOp, then downstream to PACU, and then hospital-wide.
- ☐ Accessible and visible data via the CSIS having high data quality and data integrity.
- ☐ Empowered multi-disciplinary teams and integrated knowledge workers who are perioperative subject matter experts and IT literate.
- ☐ An organizational culture focused on continuous improvement using data-driven decision-making.
- ☐ A BPM approach to perioperative performance and improvement that is aligned to hospital strategy.

## **CONCLUSION AND LIMITATIONS**

This paper fills a healthcare literature gap noted by Agarwal et al. (2010) in examining the integration and use of CSIS data and EMRs leveraged as health IT. Likewises, this study contributed to the healthcare IT literature

by examining perioperative digital transformation through the lens of IT impact to prescribe an a priori framework to foster the occurrence. Moreover, empowered teams, integrated IS coupled to workflow, leveraged health IT, and a holistic BPM approach supported this study's observed effects in the digital transformation of a hospital's perioperative process. The observed effects demonstrated CPI, BPR and BPM as adaptable practices when leveraging health IT for digital transformation within the hospital environment. Likewise, the analysis, evaluation, and synthesis cycle of CPI, BPR, and BPM 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 if a hospital's IS architecture lacked the 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 and BPM framework within their perioperative environment.

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