Abstract

This study examines electronic medical records (EMRs) applied within the hospital environment to monitor, measure, and improve perioperative workflow and patient care documentation. This paper identifies how dynamic technological activities of analysis, evaluation, and synthesis, applied to internal and external organizational data, can highlight complex relationships within integrated hospital processes to target opportunity for improvement and ultimately yield improved capabilities. The identification of existing limitations, potential capabilities, and the subsequent contextual understanding of perioperative workflow events coupled to EMRs for documentation are contributing factors that yield opportunities for measured perioperative improvement. Based on a 134-month longitudinal study of a 1,046 registered-bed academic medical center, this case study investigates EMRs impact through integrated information systems’ to improve perioperative workflow efficiency, patient care documentation, and tightened process to hospital information systems coupling. The theoretical and practical implications and study limitations are also discussed with respect to practitioners and researchers alike.

Keywords

Perioperative workflow, patient care documentation, business process management, electronic medical records.

Introduction

Integrated information systems (IS) offer continuity through information sharing, synergy, and improvement (Karimi, 1988). Likewise, integrated hospital IS and information technology (IT) provide measurement and subsequent accountability for healthcare quality and cost, creating a dichotomy (e.g., quality versus cost) that represents the foundation for healthcare improvement (Doughtery & Conway, 2008). Moreover, the American Recovery and Reinvestment Act of 2009, the Joint Commission on Accreditation of Healthcare Organizations (TJC), and Centers for Medicare & Medicaid Services (CMS) require performance and clinical outcome reporting as evidence of organizational quality, efficiency, and effectiveness. To meet these demands, 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).

Within the hospital environment, patients and their care are the focus of work. Specifically, a hospital’s perioperative process provides surgical care for inpatients and outpatients during preoperative, intra-operative, and immediate post-operative periods. Accordingly, the perioperative process reflects patient flow, safety, and quality of care as well as stakeholders’ satisfaction (i.e., patient, physician, nurse, perioperative staff, and hospital administration).

Perioperative improvement ultimately affects patient quality of care as well as hospital operational and financial performance. Operationally, a hospital’s perioperative process requires multidisciplinary teams to maneuver
Within complex, fast-paced, and critical situations—the hospital environment (McClusker et al., 2005). Improving accurate, timely perioperative patient care, flow, and documentation is both a challenge and an opportunity (Fowler et al., 2008). 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 (e.g., 33%) category being the perioperative process (Macario et al., 1995).

This research investigates how perioperative EMRs, developed through a business process management (BPM) approach, yield improved: (1) workflow, (2) process to hospital IS coupling, and (3) patient care documentation. The investigation method covers a longitudinal study of a clinical scheduling IS (CSIS) implementation, integration, and use. The resulting systematic analysis and subsequent contextual understanding of the perioperative process coupled to the integrated CSIS yielded opportunity for measurement and ultimately, improvement.

This paper prescribes an a priori approach for improved perioperative workflow and patient care documentation through the application of real-time EMRs. The following sections review previous literature on BPM, key performance indicators (KPIs), and perioperative patient care. Following the literature review, we present our methodology, case background, results, and a discussion of the observed effects. The conclusion also addresses study implications and limitations.

**Literature Review**

Industry competition, first mover advantage on innovations, adaptation of better management practices, and/or government regulations are a few of the drivers for process improvement. Traditionally, the hospital environment lacked similar industry pressures beyond government regulations. However, hospitals face increasing pressure to provide evidence of improvement in respect to organizational quality, efficiency, and effectiveness (Catalano & Fickenscher, 2007; Marjamaa et al., 2008; PwC, 2012). To this end, BPM provides a framework to measure and target process improvement (Jeston & Nelis, 2008). Measured utilization of these practices in healthcare is not a result from any lack of research as an extensive body of knowledge exists concerning the application of these approaches (Alabnese et al., 2010; Eichhorn, 2013; Herzer et al., 2008; Meyer & Driscoll, 2004; Schnall et al., 2012; Silverman & Rosenbaum, 2009). However, the literature suggests such practices and interventions yield wide variations of success.

**Business Process Management (BPM)**

Our 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 process performance improvement to meet organizational objectives. To this end, BPM embraces the concept of continuous process improvement aligned with business strategy.

Continuous process improvement (CPI) is a systematic approach toward understanding the process capability, the customer’s needs, and the source of observed variation. Tenner and DeToro (1997) view CPI as an organizational response to an acute crisis, a chronic problem, and/or an internal driver. The incremental improvement gains occur through an iterative cycle of analysis, evaluation, and synthesis or plan-do-study-act (Walton, 1986) to minimize observed variation. CPI encourages bottom-up communication at the day-to-day operations level (e.g., patient level) and requires process data comparisons to control metrics. Doubt can exist as to whether: CPI addresses symptoms versus causes; the improvement effort is sustainable year after year; and/or management is in control of the process (Jeston & Nelis, 2008).

BPM embraces the ability to quantify organizational control metrics. Business analytics is the body of knowledge identified with technology solutions that incorporate dashboards, 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 (Tenner & DeToro, 1997). 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/IT only yield high-quality healthcare when knowledge workers adapt IS/IT use patterns to their environment. Therefore,
BPM success has a strong dependence on contextual understanding of end-to-end core business processes (Jeston & Nelis, 2008).

**Perioperative Key Performance Indicators (KPIs)**

An integral part of CPI is process information before and after intervention. Hence, performance measurement is essential for purposeful BPM. Early in the IT literature, Ackoff (1967) proposed IS design should embed feedback as control to avoid management misinformation. Similarly through IS feedback (Munroe & Wheeler, 1980; Rockart, 1979; Zani, 1970), organizations define data measurement as KPIs to assist management in monitoring critical success factors (CSFs) for organizational action (i.e., business processes). However, the perioperative process is complex and information intensive (Fowler et al., 2008). Moreover, doubt exists as to whether perioperative management can meet increasing demands for cost effectiveness (Catalano & Fickenscher, 2007).

The following scenario illustrates the complexity, dynamic nature, and nested operational, tactical, and strategic relationships among perioperative KPIs. Operating room (OR) schedules are tightly coupled to an individual OR suite, patient, and surgeon. When preoperative tasks are incomplete or surgical supplies are not readily available at time of surgery, the scheduled case is delayed as well as the subsequent scheduled cases in the particular OR suite or for the particular surgeon. Operational and tactical KPIs in managing and optimizing a hospital’s perioperative process include: (1) monitoring the percentage of surgical cases that start on-time (OTS), (2) OR turn-around time (TAT) between cases, (3) OR suite utilization (UTIL), and (4) labor hours per patient care hours or units-of-service (UOS) expended in surgical care (Herzer et al., 2008; Kanich & Byrd, 1996; Peters & Blasco, 2004; Tarantino, 2003; Wright et al., 2010). 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 (i.e., OTS, TAT, UOS, or UTIL) affect strategic CSFs of patient safety, patient quality of care, surgeon/staff/patient satisfaction, and hospital margin (Marjamaa et al., 2008; Peters & Blasco, 2004).

**Perioperative Patient Care**

Specialized physicians (e.g., surgeons and anesthesiologists), nurses, and staff provide pre-operative, intra-operative, and immediate post-operative patient care. Hence, patient care occurs via perioperative teamwork with specific roles and activities that require awareness, communication, and coordination. Surgeons evaluate, prescribe, and 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’ instructions, as well as monitor and record all patient care activity. Perioperative staffs facilitate location, supplies, instruments, and equipment per physician instructions. As a result, perioperative care yields patient end-state goals: (1) a patient undergoes a surgical procedure; (2) minimal exacerbation of existing disorders; (3) avoidance of new morbidities; and (4) subsequent prompt procedure recovery (Silverman & Rosenbaum, 2009).

Workflow complexity is a barrier to perioperative patient end-state goals (Fowler et al., 2008). Inaccurate and/or incomplete patient care documentation (Schnall et al., 2012) risks end-state goals and endangers patient safety (Ilan & Fowler, 2005; Eichhorn, 2013). Emergency surgery patients (Weissman & Klein, 2008) or intensive care surgery patients with unplanned discharges (Utzolino et al., 2010) complicate patient care yielding increased post-operative recovery requirements with higher mortality rates. Furthermore, nurse-staffing increases to decrease mortality rates are contingent upon the quality of the nurse work (i.e., workflow) environment (Aiken et al., 2011).

Perioperative workflow practices can support patient care end-state goals. Accurate and complete nursing care documentation is essential to communicate and coordinate subsequent patient care (Pirie, 2011). For example, integrating relevant patient care documentation from outside the perioperative process eliminates duplication within (Frost, 2013). Pre-operative integrated evaluations communicate and document practitioner-patient awareness to avoid conflicts and identify potential OR specific risks (Silverman & Rosenbaum, 2009). Similarly, computerized provider order entry (CPOE) communicates, coordinates, and documents provider prescribed patient care and can improve patient outcomes (Rothschild, 2004).

**Research Method**
This research investigates how perioperative patient care EMRs can yield improved workflow, process to hospital IS coupling, and patient care documentation, all applied using a business process management (BPM) approach. 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.

Our research site (University Hospital) is an academic medical center, licensed for 1,046 beds and located in the southeastern United States. University Hospital is a Level 1 Trauma Center, with a robotics program encompassing over eight surgical specialties as well as a Women's/Infant facility. University Hospital's recognition includes Magnet (Aiken et al., 2011) 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 2014, with particular historical data since 1993. During the 134-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 (PRE-OP), Central Sterile Supply (CSS), OR Surgery and Endoscopy, and Post Anesthesia Care Units (PACU). The following sections highlight tools, events, and outcomes that have shaped the BPM approach across UHPS.

CSIS Implementation

UHPS implemented a new CSIS in August 2003, after using its prior CSIS for 10 years. The CSIS supports OLAP tools, a proprietary structured query language, and both operational and managerial data stores (i.e., operational data and a separate perioperative data mart). Flexible routing templates or surgical preference cards (SPC) allow standardization of surgical care data (i.e., particular supplies and instruments needed) or customization for specific surgeons and/or procedures. Since the CSIS implementation, over 7,750 generic and specific SPC configurations (Ryan et al., 2014a) facilitate the surgical specialty services (SSS) represented in Table-1.

November 2004

University Hospital opened a new surgical facility in November 2004, with ORs located over two floors and CSS located on a third. The move expanded UHPS to cover an additional floor and nine additional ORs (i.e., 33% capacity increase). The new facility housed 40 state-of-the-art OR suites, each having new standard as well as surgical specialty equipment. Within six weeks of occupying the new facility, a scheduling KPI reflected chaos. Surgical case OTS plunged to 18% during December 2004. Within a highly competitive hospital industry, having only 18% OTS was unacceptable, as 82% of scheduled surgeries experienced delays and risked patient care and safety.

Perioperative Improvement

In January 2005, UHPS expressed concerns before a quickly convened meeting of the c-level executive officers and top representatives of surgeons and anesthesia. The meeting yielded a hybrid management structure and governance in the formation of a multidisciplinary executive team, chartered and empowered to evoke change. The executive team consisted of perioperative stakeholders (i.e., surgeons, 

<table>
<thead>
<tr>
<th>Surgical Service Specialty (SSS)</th>
<th>SPCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>BURN – Trauma burns</td>
<td>26</td>
</tr>
<tr>
<td>CARDIO – Cardiovascular &amp; Thoracic</td>
<td>946</td>
</tr>
<tr>
<td>ENT – Ear, Nose, &amp; Throat</td>
<td>1,030</td>
</tr>
<tr>
<td>GI – Gastro-intestinal</td>
<td>460</td>
</tr>
<tr>
<td>GYN – Obstetrics, oncology, incontinence</td>
<td>611</td>
</tr>
<tr>
<td>NEURO – Neurological</td>
<td>763</td>
</tr>
<tr>
<td>ORAL – Oral Maxil Facial</td>
<td>236</td>
</tr>
<tr>
<td>ORTHO – Orthopedic, joint/device</td>
<td>1,208</td>
</tr>
<tr>
<td>PLAS – Plastic surgery</td>
<td>681</td>
</tr>
<tr>
<td>SURG ONC – Surgical oncology</td>
<td>329</td>
</tr>
<tr>
<td>TX – Transplants (liver, renal)</td>
<td>394</td>
</tr>
<tr>
<td>TRAUMA – Trauma, MASH</td>
<td>203</td>
</tr>
<tr>
<td>URO – Urology</td>
<td>533</td>
</tr>
<tr>
<td>VASCULAR – arteries &amp; blood vessels</td>
<td>558</td>
</tr>
</tbody>
</table>

Table-1 – University Hospital SSS
anesthesiologists, nurses, and UHPS). The executive team’s charter was to focus on patient care and safety, attack difficult questions, and remove inefficiencies. No issue was off-limits.

University Hospital's executive team launched a process improvement effort in 2005 to address the perioperative crisis through soft innovations (Ryan et al., 2008). As a result, the executive team enlisted numerous task forces to address specific problems and/or opportunities, which was the foundation for their BPM approach. All initiatives were data-driven from the existing integrated hospital IS. Supporting data identified problem areas, strengths to highlight, and direction for improvement. Each identified problem area presented a new goal proposal and strategy for implementation.

Since 2005, UHPS has focused on data-driven, systematic analysis of perioperative KPIs to gauge process variance and improve end-to-end workflow. Perioperative KPI feedback occurs at strategic, tactical, and operational levels via balanced scorecards and dashboards, aligned to hospital strategy (Ryan et al., 2014b). Using this BPM approach, improvement efforts have targeted OR scheduling (Ryan et al., 2011a); hospital-wide EMR integration (Ryan et al., 2011b); preoperative patient evaluations (Ryan et al., 2012); radio-frequency identification (Ryan et al., 2013); and CSS/OR supply workflow (Ryan et al., 2014a).

**Patient Flow and Integrated Hospital IS**

![Figure-1 - UHHS Patient Flow](image1)

![Figure-2 - UHHS Integrated IS](image2)

Given the perioperative improvement success, hospital administration consolidated all OR management and scheduling within the University Hospital Health System (UHHS) under UHPS in 2008, including cardio-vascular and off-site surgical clinics. In 2011, hospital administration added the preoperative assessment consultation and test (PACT) clinic (Ryan et al., 2012) to UHPS’ scope. Currently within UHHS, UHPS manages 34 general OR suites (GENOR), 6 cardio-vascular OR suites (CVOR), 16 OR suites on the Highlands campus (HHOR), 2 OR suites at Women & Children (WaCOR), and 9 OR suites at the CAL Eye Foundation Hospital (CEFOR). In total, UHPS manages 67 OR suites having a combined FY2014 surgical case volume of 42,741.
As depicted in Figure-1, patient admissions are either medical or surgical. Surgical patient admissions occur via three venues: 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. The PACT Clinic exists virtually in the CSIS, so the TK Clinic allocated physical space to facilitate PACT evaluations.

IS identify structural relationships, interactions, information flow, and functionality (Nunamaker et al., 1991), where IS integration is an attempt toward improvement (van Deursen, 1999). At the organizational level, integrating disparate IS cut across political boundaries, manipulate organizational structure, transform culture, and alter power distribution (Burkhardt & Brass, 1990; Keen, 1981; Robey & Boudreau, 1999). At the patient level, the clinical use of IS/IT integration in acute critical care settings improves patient monitoring, bedside charting, and artificial support devices (Rothschild, 2004). 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.

All IS depicted in Figure-2 are integrated with either bi-directional data exchange or uni-directional for limited 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 HIPAA (i.e., Health Insurance Portability and Accountability Act of 1996) compliant Web services and biomedical device interface bus (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.

**Case Results of Perioperative Workflow Events via EMR Documentation**

Surgical UHHS patients move through the perioperative workflow via events: (1) A clinic visit resulting in surgery scheduling, (2) PACT Clinic evaluation, (3) day of surgery admission, (4) PRE-OP, (5) Intra-operative or Endoscopy procedure, (6) PACU, (7) PACU Phase-II, and (8) discharge or movement to a medical bed. The following sections review perioperative patient care during these workflow events and the corresponding EMR documentation via the integrated hospital IS (i.e., Figure-2).

**Surgery Scheduling (1)**

Surgeons, surgeons’ staffs, or SSS staffs schedule a patient’s surgical procedure from their office via the CSIS, with synchronous scheduling of PACT Clinic evaluation appointments. Released OR suites and available openings in the SSS OR schedule are visible for selection as depicted in Figure-3. In the CSIS, the surgeon, or staff per surgeon’s request, creates a surgical case for a patient’s procedure using a SPC (i.e., Table-1).

Posting the surgical case into the OR schedule queue creates an ambulatory EMR with standardized associated surgical procedure orders for the patient (i.e., from the Clinical Plans of Care IS). Via the Clinical Charting IS (e.g., CPOE), the surgeon or designated staff can add customized orders to the EMR from available options reflected from templates pre-
configured in the Clinical Plan of Care IS. Figure-4 depicts the categories of CPOE orders available via the Clinical Plan of Care IS. The EMR also accepts pertinent external records (i.e., external UHHS medical records) as attachments.

**PACT Clinic Evaluation (2)**

During the PACT evaluation, the surgeon performs a focused surgical assessment of the patient and confirms surgical consent, documenting the results into the patient’s case clinic notes via the CSIS. The surgeon may also order cardiac/diagnostic testing or a cardiac/medical consultation as needed via the CPOE, which authorizes and requests the services via the corresponding ancillary IS. All test results (e.g., Stress, EKG, Imaging/Xray, or Lab) post to the patient’s EMR via the BDIB (i.e., Figure-2). Cardiac/medical consultation documentation occurs via the Clinical Charting IS (i.e., Figure-2). Figure-5 depicts a screenshot of the PACT evaluation documentation EMR.

Also during the PACT evaluation, a PRE-OP nurse completes the patient’s PRE-OP Nursing Assessment Record via the CSIS. The PRE-OP Nursing Assessment Record documents the patient’s complete preoperative medical history, physical exam, confirmation of informed surgical consent, optimized medications, and patient education.

**Day of Surgery Admissions (3)**

Patient admissions occur via the Patient Mgt. / Billing IS depicted in Figure-2. During Admissions, perioperative staff document patient family/advocate contact information via the CSIS as an Ancillary Services Record for Patient Family Communication and informs the patient family/advocate how to check the patient’s location or status. Figure-6 depicts a patient family record screenshot and Figure-7 depicts the Family Link Color Legend for patient status inquiries.

After Admissions, the CSIS updates a HIPAA compliant visible interface to a patient’s case status (e.g., both outpatient and in-patient), including the in-patient’s location after PACU discharge, over wall-mounted, color-coded displays throughout UHPS. Via real-time clinical updates to
the patient’s case in the CSIS, patient family/advocate can track patient progress. UHPS clinical staff use the displays to anticipate patient’s arrival, interact electronically with the patient’s EMR as well as the patient’s surgical case record across the perioperative process. Figures 8 and 9 depict patient status boards in PACU and an OR waiting room, respectively.

**PRE-OP (4)**

PRE-OP nurses prepare patients for their surgical procedures per physician orders (i.e., CPOE and Pharmacy IS from Figure-2) and provide acute patient care after anesthesia. Within the CSIS, a Regional Block Nursing Record or Endo Sedation Nursing Record posted to the patient’s surgical case identifies when acute patient care begins in PRE-OP. The clinical documentation identifies acute care, which incurs higher patient UOS charges. Within the CSIS, both PRE-OP acute care records (e.g., Regional Block and Endo Sedation) capture the higher UOS charges that flow through to the Budgeting IS (i.e., from Figure-2). Figure-10 depicts a screenshot of all the CSIS nursing records (i.e., EMRs) associated with different patient UOS charge levels. Figure-11 depicts an Endo Sedation Nursing Record screenshot from PRE-OP.

![Figure-10 - CSIS Nursing Records](image1)

![Figure-11 – Endo Sedation Nursing Record](image2)

**Intra-operative or Endoscopy (5)**

Anesthesiologists’, surgeons’, and intra-operative staff’s’ schedules are dynamically linked and distributed over the wall-mounted displays throughout the OR facilities via the CSIS, informing clinical stakeholders when surgical patients’ cases are scheduled, in-progress, completed, or shifted from one OR suite or scheduled time slot to another. Prior to the PRE-OP patient’s arrival, OR staff setup the scheduled suite according to SPC specific equipment, devices, and particular CSS case cart. Intravenous medications (i.e., CPOE, Pharmacy IS, and medication distribution devices via Figure-2) are available as ordered or needed. The CSS prepared case cart (i.e., up to 8-hours in advance) contains supplies and instruments for the patient’s specific surgical procedure per the surgeon’s selected SPC and CPOE.

Once the patient arrives, an OR nurse begins the OR Nursing Record data entry via the CSIS. The OR Nursing Record documents all people, time, and activities while the patient is in the OR as required by TJC and CMS as well as all medication, blood, tissue, and supply usage. Within the CSIS, the OR Nursing Record captures UOS time and supply charges that flow through to the Patient Mgt./Billing IS and on through to the Budgeting IS (i.e., as depicted from Figure-2).

A specific OR Nursing Record EMR reflects actual UOS time and supply charges for the specific intra-operative or endoscopic procedure. Other CSIS intra-operative documentation captured on the OR Nursing Record EMR includes quality issues for patient longitudinal outcomes, retained object counts, and robotic usage. CSIS clinical data collection also occurs via the BDIB (i.e., Figure-2), from sophisticated medical equipment like cardio-
vascular perfusion, sensor monitors for patient’s vital signs, or smart cabinets that transfer tissue transplant traceability to the patient’s EMR. The final intra-operative CSIS documentation occurs after the surgical case completion, while the patient is in transport from the OR suite to PACU. The OR staff enters an Ancillary Services Record Room Cleanup to document the UOS spent on the OR suite clean up and setup for the next scheduled surgical patient (e.g., documented TAT).

**PACU (6)**

PACU nurses receive surgical patients from the OR and continue acute care per physicians' orders. The PACU Nursing Record, entered via the CSIS, documents acute perioperative care delivery while a patient recovers from anesthesia. PACU is a critical care unit similar to the OR suite and the CSIS collects clinical patient data from biomedical equipment and monitoring sensors (i.e., BDIB from Figure-2).

![Figure-12 - ICU/After Hours PACU Overflow Record](image1)

![Figure-13 - PACU Phase II Nursing Record](image2)

**Critical care patients can remain in PACU after anesthesia recovery if needed due to intensive care units (ICU) capacity constraints. The ICU/After Hours PACU Overflow Record, entered via the CSIS, documents acute care for patients that are over-nighting in PACU due to overflow conditions in the ICU as well as captures the correct ICU patient UOS charges for critical care. Figure-12 depicts an ICU/After Hours PACU Overflow Record screenshot.**

**PACU Phase-II (7)**

As surgical patients recover from anesthesia, the need for acute care lessens. Within the CSIS, a PACU Phase-II Nursing Record posted to the patient’s surgical case identifies when PACU acute care ends. PACU Phase-II Nursing Records document ambulatory care that has lower patient UOS charges and allows any UHHS hospital bed having ambulatory patient care to become PACU Phase-II, creating a virtual PACU in the CSIS and reserving the physical PACU beds for acute or critical care patients. Figure-13 depicts a PACU Phase II Nursing Record.

**Discharge or Movement to Bed (8)**

When surgical patients completely recover from anesthesia, the attending nurse discharges the patient from Phase-II and discontinues documentation to the patient’s surgical case. Likewise, post-operative staffs discharge outpatients per surgeon orders, while in-patients move to a hospital bed. Discharged or in-patient transportation requests occur via the Patient Transport IS (i.e., Figure-2).

**Analysis and Discussion**

The previously reviewed workflow events and corresponding UHPS nursing records demonstrate a tight coupling between perioperative patient care documentation, workflow, and the integrated hospital IS. The final
implementation of UOS charge capture through EMR documentation in 2014 fully automated the data collection for the UOS KPI. Hence, the CSIS coordinates, facilitates, documents, and reports patient level quality of care, progress, safety, and outcomes. Furthermore, CSIS nursing EMRs for patient care documentation (i.e., Figure-10) yield aggregated quantitative surgical case (e.g., patient) data as means to understand, manage, and improve perioperative workflow and performance at operational, tactical, and strategic levels.

**CSIS Patient Care Documentation via EMR**

UHPS developed and configured unique CSIS nursing records (i.e., Figure-10) as EMRs to manage patient care documentation across the perioperative workflow. UOS standards reflect perioperative staff labor hours associated with particular patient care activity units—one hour of patient care time, an Endoscopy procedure, or a sterilized instrument load. UOS metrics reflect patient care hours in each workflow segment. Table-2 lists the current CSIS nursing record documentation via EMR, the fiscal year of the UOS charge capture implementation, UOS standard labor hours, and UOS unit.

<table>
<thead>
<tr>
<th>CSIS Documentation via EMR</th>
<th>FY Start</th>
<th>UOS Standard</th>
<th>UOS Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ancillary Services Record - Family</td>
<td>2007</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Preop Nursing Assessment</td>
<td>2012</td>
<td>1.93</td>
<td>Time</td>
</tr>
<tr>
<td>Endo Preop Nursing Record</td>
<td>2014</td>
<td>--</td>
<td>Procedure</td>
</tr>
<tr>
<td>Endo Sedation Nursing Record</td>
<td>2014</td>
<td>2.1</td>
<td>Time</td>
</tr>
<tr>
<td>Regional Block Nursing Record</td>
<td>2014</td>
<td>2.21</td>
<td>Time</td>
</tr>
<tr>
<td>CSS</td>
<td>2003</td>
<td>3.52</td>
<td>Sterilized Loads</td>
</tr>
<tr>
<td>OR Nursing Record - CVOR</td>
<td>2007</td>
<td>9.04</td>
<td>Time</td>
</tr>
<tr>
<td>OR Nursing Record - Cardiac Perfusion</td>
<td>2012</td>
<td>4.22</td>
<td>Time</td>
</tr>
<tr>
<td>OR Nursing Record - GENOR</td>
<td>2003</td>
<td>7.45</td>
<td>Time</td>
</tr>
<tr>
<td>OR Nursing Record - ENDO</td>
<td>2014</td>
<td>6.92</td>
<td>Procedure</td>
</tr>
<tr>
<td>Ancillary Services Record – Room Cleanup</td>
<td>2005</td>
<td>--</td>
<td>Time</td>
</tr>
<tr>
<td>PACU Nursing Record</td>
<td>2010</td>
<td>2.71</td>
<td>Time</td>
</tr>
<tr>
<td>ICU/After Hours PACU Overflow Record</td>
<td>2014</td>
<td>2.71</td>
<td>Time</td>
</tr>
<tr>
<td>PACU Phase-II Nursing Record</td>
<td>2014</td>
<td>1.93</td>
<td>Time</td>
</tr>
</tbody>
</table>

**Table-2 – CSIS Nursing Care Documentation and UOS**

Prior to the implementation of each real-time UOS charge capture via EMR documentation, perioperative staff manually batch-keyed UOS charges. As of March 2014, all CSIS nursing documentation via EMRs capture UOS charge data (e.g., UOS standard multiplied by UOS units) using the appropriate UOS standards and units. UHPS use the granularity in the aggregated UOS charge data for perioperative process OLAP to offer contextual understanding to analyze process variances, target improvement areas, and justify resource allocations.

CSIS nursing records with UOS standards differentiate staffing labor hours for different levels of patient care. Within PACU, the Phase-II and ICU nursing records also facilitate PACU workflow and bed/resource utilization. Moreover, the ICU Overflow record identifies ICU capacity issues to avoid unplanned ICU discharges (Utzolino et al., 2010).

CSIS nursing records without UOS standards facilitate information collection on patient family/advocate, Endoscopy patient status, or surgical case OR suite TAT. All OR Nursing Record EMRs also provide documentation for OR suite OTS and UTIL measures.

**Aggregated KPIs and BPM**

Figures 14, 15, and 16 depict aggregated surgical case (i.e., patient) data for perioperative process performance on OTS, UTIL/OTS/TAT, and UOS, respectively. Figure-14 depicts the yearly OTS averages for GENOR, CVOR, and HHOR surgical cases since FY2006 (i.e., UHHS fiscal year begins in October). The chart helps visualization of aggregate workflow performance improvement in providing efficient perioperative patient care while limiting unnecessary patient safety risk. From a BPM approach, these charts also help visualize where perioperative
teams and task forces should target improvement. Since the full implementation of the PACT Clinic during FY2012, over 70% of surgical cases in GENOR, CVOR, and HHOR started on-time. Prior to FY2013, the OTS 70% target was elusive, in part to incomplete PREOP documentation, which PACT Clinic evaluations eliminated (Ryan et al., 2012).

Figure-15 details UTIL, OTS, TAT, and modified-block released time (Ryan et al., 2011a; Peters & Blasco, 2004) by SSS for April 2014. The chart demonstrates granularity and dimensionality of aggregated patient data used in the systematic analysis of process performance. UHPS uses the detailed dimensionality of KPI data to identify specific performance results as well as target specific improvement opportunity.

Aggregated UOS data offers similar analysis capabilities for contextual understanding of patient care workflow dynamics and complexity. Figure-16 reports the UOS patient hours for GENOR and CVOR workflow since FY2006. In Figure-18, the FY2013 spike in PACU hours, up 12K hours (i.e., 32% increase) from FY2012, is attributable to ICU overflow patient care in PACU (i.e., extended-stay PACU patients waiting for an ICU bed or ICU patients over-nighting in PACU). UHPS use PACU beds to relieve Trauma-ICU and Surgical-ICU patient workflow congestion, moving PACU Phase-II patient care to PREOP beds. In December 2013 (e.g., FY2014), UHPS implemented Phase-II and ICU Overflow nursing records in PACU via the CSIS to document the workflow flexibility and capture UOS charges. As a result, FY2014 hours reflect the virtual PACU flexibility and tightened the CSIS-to-PACU workflow coupling.

In combination, aggregated KPIs offer further contextual understanding. Using UOS and case volume, the GENOR surgical case volume increased 8% between FY2006 and FY2014, compared to a corresponding 17% UOS hour increase. Restated using case volume, OTS, and UOS KPIs—GENOR teams performed 8% more surgical procedures in FY2014 than FY2006, requiring 17% more patient care. The FY2014 average surgical procedure took 2.9 hours of OR time, up from 2.7 in FY2006, and 79% of the FY2014 procedures started on time compared to 62% in FY2006.
Practical and Theoretical Contributions

Empowered teams, integrated IS coupled to workflow, and a holistic BPM approach support University Hospital’s perioperative process. This study contributes to healthcare IT literature and fills a gap by demonstrating how unique and customized perioperative nursing documentation via EMRs can highlight workflow and patient care documentation, collect performance measurements, and be used as a management tool. This study also prescribed an a priori framework to foster the occurrence. Researchers may choose to further or expand the investigation, while practitioners may adopt the practices within their perioperative process. Moreover, this study demonstrated CPI and BPM application in the hospital environment using EMRs tightly coupled to the perioperative workflow. The CPI/BPM cycle of analysis, evaluation, and synthesis also reinforces communication and stimulates individual as well as collective organizational learning.

This study is limited to a single case, where future research should broaden focus as well as address other issues inadvertently overlooked. The case examples can serve as momentum for perioperative methodology, complexity comprehension, and improvement extension. The study results were exploratory and need further confirmation.

REFERENCES


