Data Quality Assurance via Perioperative EMR Reconciliation

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Abstract

This research examines systematic quality control checks (QCCs) developed to safeguard the data quality assurance of perioperative electronic medical records (EMRs). The resulting perioperative EMR reconciled data supports patient care documentation, patient billing, perioperative data analysis, and regulatory agency audits. This case study identifies specific perioperative nursing care documentation as EMRs and demonstrates how data QCC rules, an embedded QCC review process, and QCC rule violation reconciliation applied to perioperative EMRs are applicable to ensure data quality within integrated hospital information systems. Identification of existing limitations, potential capabilities, and the subsequent contextual understanding yield an a priori framework for data quality assurance of perioperative process EMR data. Based on a 174-month longitudinal study of a large 1,157 registered-bed academic medical center, the case results are discussed as well as theoretical and practical implications with study limitations.

Keywords

Embedded quality control checks, data quality, electronic medical records, perioperative process data, and business process management.

Introduction

Integrated information systems (IS) offer continuity through information sharing and synergy (Karimi, 1988), where IS integration is an attempt toward improvement (van Deursen, 1999). 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). In the United States, the American Recovery and Reinvestment Act of 2009, the Health Information Technology for Economic and Clinical Health Act, the Affordable Care Act, 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 (Blumenthal, 2012). Meeting these demands require administrators and medical professionals alike to leverage IS and IT that yield quality patient care and safety, coupled with increased efficiency and cost effectiveness (PwC, 2012). Successfully meeting these challenges requires maintaining indisputable data quality (i.e., completeness and timeliness) and data integrity (i.e., validity and consistency) for all real-time, integrated hospital information systems. Consequently, the recent widespread IS/IT adoption across healthcare in the United States also necessitates the need for value realization (CMS, 2014; Jones et al., 2014). From a business perspective, the implementation of new technologies often implies changes in value creation, which impact digital transformation strategies on firms’ value chains and offer improvement opportunities, accompanied by requirements for different technology related competencies (Matt, Hess, & Benlian, 2015).

Within the hospital environment, patients and their care are the focus of work. To this end, a hospital's perioperative process involves multiple interconnected sub-processes that yield surgical care for
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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 its complexity challenges multidisciplinary teams to maneuver within fast-paced and critical situations (McClusker et al., 2005). Compounding factors of complexity and urgency affect patient quality of care, patient flow, patient safety, operational efficiency, financial performance, as well as stakeholders’ satisfaction (i.e., patient, physician, nurse, perioperative staff, and hospital administration). To this end, electronic documentation and reporting of patient experiences and outcomes during perioperative sub-process activities within an integrated hospital information system provides evidence for regulatory agencies (e.g., TJC and CMS) and third party payers, as well as internal performance reporting and improvement efforts through business process management (BPM).

This research investigates embedded data quality control checks, used in a BPM framework, to ensure perioperative data quality for: (1) patient care documentation, (2) patient billing, (3) perioperative data analysis, and (4) regulatory agency audits. 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 improvement in technology related competencies.

This paper prescribes an a priori approach for embedding data quality assurance into perioperative process data via cross-checking contents and data quality during automated reconciliation of real-time electronic medical records (EMRs). The following sections review previous literature on data quality versus data integrity, BPM, key performance indicators (KPIs), along with CMS quality standards and reimbursements. 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 examples of the many factors that drive process improvements. Traditionally, the hospital environment lacked similar industrial pressures beyond government regulations. However, hospital administration currently face increasing pressure to provide objective evidence of patient outcomes in respect to organizational quality, efficiency, and effectiveness (CMS, 2005; CMS, 2010; PwC, 2012), all while preserving or improving clinical quality standards. To this end, industrial and operations management practices, borrowed from BPM, provide a framework to target and measure improvement (Jeston & Nelis, 2008; Tenner & DeToro, 1997).

Data Quality versus Data Integrity

The IS literature has yielded numerous perspectives and dimensions of data quality, with this research choosing to define data quality over five dimensions detailed in Lee & Strong (2003) and later by Weiskopf & Weng (2013). Lee & Strong (2003) empirically identified knowledge as an important prerequisite for producing high-quality data that reflects accuracy, completeness, accessibility, timeliness, and relevancy. Weiskopf & Weng (2013) later identified similar data quality dimensions within EMRs over correctness (i.e., accuracy), completeness, concordance (i.e., accessibility), currency (i.e., timeliness), and plausibility (i.e., relevancy). Furthermore, Strong et al. (1997) defines data quality as data fit for use, where fitness for use produces accurate, complete, and timely data accessible to stakeholders and relevant to their tasks.

Gertz (1998) defines traditional data integrity as validation of existing correctness or congruence between fields of data stored in a database by means of logic-based formulas (e.g. tuple relational calculus). This definition differentiates the two terms, where data integrity concerns stored data while data quality relates to data fit for use in the context of how the data in the information system models the real world (Getz, 1998). Hence, data integrity issues will lead to low data quality. Nonetheless, data integrity may not correct poor data quality from lack of accuracy, completeness, accessibility, timeliness, and relevancy. Furthermore, poor data integrity and/or poor data quality within information systems yield flawed information, which when used in decision making yield flawed decisions. Hence, integrated hospital information systems require data with integrity and quality to yield viable decision alternatives, assist in
critical decision-making, as well as to yield accurate, complete, accessible, timely, and relevant information that reflect patient events, experiences, and outcomes. To this end, integrity maintaining mechanisms can be easily embedded within information systems as routines or processes and databases as triggers or stored procedures (Gertz, 1998). Lee et al. (2004) recommends embedding data integrity within the data process as a continuous data quality improvement, dynamic in nature to address changes in business processes and capture data that models events from the real world.

**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 at the day-to-day operations level and requires process data comparisons to control metrics. Incremental improvement gains occur via iterative cycles of analysis, evaluation, and synthesis or plan-do-study-act (Walton, 1986) to minimize observed variation. Doubt can exist: whether the incremental improvement addresses symptoms versus causes; whether the improvement effort is sustainable year after year; or whether management is in control of the process (Jeston & Nelis, 2008).

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. 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., 2008). Business analytics within BPM focus on the effective use of organizational data and information to drive positive business action (Jeston & Nelis, 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 stakeholders’ contextual understanding of end-to-end core business processes (Jeston & Nelis, 2008). Furthermore, data integrity and/or data quality issues distort or inhibit stakeholder understanding.

**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. Purposeful BPM demands absolute data integrity and data quality in performance measurement to minimize bias and impart stakeholder trust. Ackoff (1967) proposed IS design should embed feedback as a control to avoid management misinformation. Likewise, Lee et al. (2004) views data integrity as dynamic, process-embedded feedback to improve data quality. Consequently, organizations define data metrics as KPIs to assist management via IS feedback in monitoring critical success factors (CSFs) (Munroe & Wheeler, 1980; Rockart, 1979; Zani, 1970) for organizational action (i.e. business processes). To this end, the perioperative process is increasingly information intensive (Catalano & Fickenscher, 2007), in part due to complexity (Fowler et al., 2008).

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 per patient care hours as units-of-service (UOS) expended (Herzer et al., 2008; Kanich & Byrd, 1996; Peters & Blasco, 2004; Wright et al., 2010). Tarantino (2003) noted how lower OR TAT and a flexible work environment are CSFs for physician satisfaction, which in turn is a CSF for hospital margin. In contrast, inefficient and ineffective processes yield poor operational and tactical KPI metrics (i.e., OTS, TAT, UOS, or UTIL) that affect strategic CSFs of patient safety, patient quality of care, surgeon/staff/patient satisfaction, and hospital margin (Marjamaa et al., 2008). Likewise, data integrity and quality issues can distort KPIs.
CMS Quality Standards and Reimbursements

CMS requires hospitals to periodically submit patient quality of care outcome measures. CMS (2010) and the Hospital Quality Alliance (HQA) began publicly reporting inpatient quality reporting (IQR) outcomes on 30-day mortality measures for acute myocardial infarction (AMI) and heart failure (HF) in 2007 and for pneumonia (PN) in 2008. Patient satisfaction measures began as the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey in 2002, a Department of Health and Human Services collaboration effort between CMS and the Agency for Healthcare Research and Quality (AHRQ). The evolved HCAHPS survey measures report patient perspectives on care received across items that encompass ten key topics (HCAHPS, 2012).

CMS (2005) also began encouraging improvements in Medicare beneficiaries’ quality of care via pay-for-performance (P4P) or value-based purchasing (VBP) as a CMS payment model that rewards healthcare providers for meeting certain performance measures in quality and efficiency. Interestingly, Lindenauer et al. (2007) found hospitals reporting P4P metrics achieve modestly greater quality improvements than hospitals engaged only in public reporting. In addition to P4P, CMS includes disincentives of reducing reimbursements (Waters et al., 2015) for negative consequences of care that should never occur, defined by the National Quality Forum (NQF, 2008), including hospital infections under the surgical care improvement project (SCIP).

The Health Insurance Portability and Accountability Act (HIPAA) of 1996 revised the United States Social Security Act and established the Medicare Integrity Program within CMS to deter fraud and abuse, which gave CMS authority to enter into contracts with outside entities in order to ensure the integrity of CMS reimbursement programs to healthcare providers (CMS, 2016). The Recovery Audit Contractor (RAC) program is an integral part of CMS’ “benefit integrity” efforts, which is responsible for highlighting common billing errors, trends, and other CMS overpayment or underpayment issues. In fiscal 2014, CMS RACs collectively identified $2.57 billion in improper payments to healthcare providers (CMS, 2016). The CMS RAC correction amount in fiscal 2015 decreased by 82.8% due to a United States Congressional oversight prohibition through October 2015 on CMS RACs performing patient status reviews until healthcare providers could fully comprehend the new CMS Inpatient Prospective Payment System Final Rule. CMS has since issued recovery audit improvements to focus the scope of RAC audits (CMS, 2016). However, data quality and integrity issues within integrated hospital information systems can initiate RAC audits, which can yield delayed to disallowed CMS reimbursement. Irreconcilable data integrity and data quality issues discovered in RAC audits can be construed as fraud and passed on to the United States Department of Justice or Office of the Inspector General. Ensuring the data integrity and quality of healthcare claims to CMS is a CSF for any healthcare provider.

Methodology

The objective of this study is to investigate how embedded data quality control checks and EMR reconciliation of data exceptions, used within a BPM framework, provides data quality assurance for downstream perioperative data consumers (e.g., knowledge workers and stakeholders). To this end, case research is particularly appropriate (Eisenhardt, 1989; Yin, 2003). Paré (2001) recommended using a positivist case study methodology to build and test theories in IS research. 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 (e.g. University Hospital) is an academic medical center, licensed for 1,157 beds and located in the southeastern United States. University Hospital is a Level 1 Trauma Center, with a robotics program across eight surgical specialties 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 January 2018, with particular historical data since 1993. During the 174-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), OR Surgery and Endoscopy, and Post Anesthesia Care Units (PACU). The workflow through CSS reprocesses all reusable surgical instruments/devices and moves supplies to pre-operative, intra-operative, and post-operative activities. 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 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 or surgical preference cards (SPCs) allow standardization of surgical care data (i.e., particular supplies and instruments needed) or SPC customization for specific surgeons and/or procedures. Since the 2003 CSIS implementation, over 7,750 generic and custom SPC configurations facilitate the surgical specialty services (SSS) represented in Table-1. Similarly, the agile 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 (e.g. North Pavilion) in November 2004. The new facility expanded UHPS’ OR capacity by 33%, providing state-of-the-art OR suites having standardized as well as surgical specific equipment. Within 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.

Perioperative Process Improvement

In January 2005, UHPS expressed concerns before a quickly convened meeting of C-level, nursing, and physician representatives. 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, 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 evaluating specific opportunities, which founded UHPS’ current BPM approach. UHPS focuses BPM on data-driven analysis of KPIs to gauge process variance, identify improvement opportunities from variances, and

Table 1 – Current SSSs and CSIS SPCs

<table>
<thead>
<tr>
<th>Surgical Specialty Service (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, gynecology</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>194</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>

Figure 1 - UHHS Integrated IS
improve end-to-end workflow. To this end, numerous BPM efforts have targeted multiple perioperative sub-processes to improve patient workflow (Ryan, Doster, Daily, & Lewis, 2016).

Since 2005, UHPS has expanded its management beyond the initial general (GENOR) and cardio-vascular (CVOR) ORs within the North Pavilion campus to the other campuses of 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 UHHS. Currently UHHS manages 58 ORs and 11 endoscopy labs. 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.

**Observed Effects**

Figure-1 depicts the integrated hospital IS used to facilitate and document perioperative patient care and outcomes across UHHS. Integration of the IS depicted in Figure-1 occur with either bidirectional data exchange or unidirectional for limited exchange. The seven IS modules clustered around the CSIS directly support and extend the CSIS suite, where the Clinical Charting IS houses CPOE and EMRs. The HIPAA compliant Web services and biomedical device interface bus (BDIB) integrate ancillary IS, clinical data sensors, and biomedical equipment. The institutional intranet serves as a single entry secured portal to extend each IS according to particular user rights and privileges negotiated upon user authentication. With respect to data quality, all the IS depicted in Figure-1 reflect real world situations across UHHS. All medical records (i.e., in-patient or out-patient), admissions, diagnostics, clinical data, observations, as well as discharges occur via the same integrated hospital IS. All perioperative material, medical devices, and labor charges captured from surgical patients' are documented with nursing EMRs in the CSIS. Charges flow from the nursing EMRs in the CSIS through to Cost Accounting, Financial, and Budgeting IS. Hence, data integrity and data quality are foundational requirements for all integrated IS depicted in Figure-1.

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. UHPS uses CSIS nursing records as EMRs to manage patient care documentation and track perioperative workflow. Each perioperative event creates an ambulatory EMR associated with the patient’s unique medical record (MRN), encounter, and case numbers. Table-2 lists current CSIS nursing documentation EMRs, the fiscal year of UOS charge capture implementation, UOS standard, UOS unit, and the associated perioperative sub-process. UOS standards reflect perioperative staff labor associated with particular patient care activities reflected in each EMR—one hour of patient care time, an Endoscopy procedure, or a sterilized instrument load. Aggregate UOS metrics reflect patient care hours by each perioperative sub-process. Nursing EMRs from the CSIS generate patient billing charges.

In October 2016, UHPS developed quality control checks (QCC) between real-time nursing EMRs to ensure data quality with respect to completeness, context, time, location, and surgeon specialty. The embedded QCC review process and corresponding BPM approach to EMR reconciliation ensures integrity and quality for perioperative data applications and other data consumers downstream. The following sections detail observed effects of the quality control checks, the quality control check review, and the EMR reconciliation. Quality Control Checks

<table>
<thead>
<tr>
<th>Sub-process</th>
<th>Perioperative Nursing EMR</th>
<th>FY</th>
<th>Std.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission</td>
<td>Ancillary Services</td>
<td>Family</td>
<td>2007</td>
<td>--</td>
</tr>
<tr>
<td>PACT</td>
<td>PreOP Nursing Assessment</td>
<td>2012</td>
<td>1.93</td>
<td>Hrs.</td>
</tr>
<tr>
<td>PreOP</td>
<td>Endo PreOP Nursing</td>
<td>2014</td>
<td>--</td>
<td>Proc.</td>
</tr>
<tr>
<td>PreOP</td>
<td>Endo Sedation Nursing</td>
<td>2014</td>
<td>2.1</td>
<td>Hrs.</td>
</tr>
<tr>
<td>PreOP</td>
<td>Regional Block Nursing</td>
<td>2014</td>
<td>2.21</td>
<td>Hrs.</td>
</tr>
<tr>
<td>CSS</td>
<td>CSS Sterilized Instruments</td>
<td>2003</td>
<td>3.52</td>
<td>Load</td>
</tr>
<tr>
<td>OR</td>
<td>OR Nursing</td>
<td>CVOR</td>
<td>2007</td>
<td>9.04</td>
</tr>
<tr>
<td>OR</td>
<td>OR Nursing</td>
<td>Cardiac Perfusion</td>
<td>2012</td>
<td>4.22</td>
</tr>
<tr>
<td>OR</td>
<td>OR Nursing</td>
<td>GENOR - HHOR</td>
<td>2003</td>
<td>7.45</td>
</tr>
<tr>
<td>OR</td>
<td>OR Nursing</td>
<td>ENDO</td>
<td>2014</td>
<td>6.92</td>
</tr>
<tr>
<td>OR</td>
<td>Ancillary Services</td>
<td>Room Clean</td>
<td>2005</td>
<td>--</td>
</tr>
<tr>
<td>PACU</td>
<td>PACU Nursing</td>
<td>2010</td>
<td>2.71</td>
<td>Hrs.</td>
</tr>
<tr>
<td>PACU</td>
<td>ICU/After Hours PACU Overflow</td>
<td>2014</td>
<td>2.71</td>
<td>Hrs.</td>
</tr>
<tr>
<td>PACU</td>
<td>PACU Phase-II Nursing</td>
<td>2014</td>
<td>1.93</td>
<td>Hrs.</td>
</tr>
</tbody>
</table>

**Table 2 – CSIS Nursing Documentation EMRs and UOS**
Data integrity solutions require flexible logic control capabilities while performing numerous types of validation (Debroux & Reed, 2015). To this end, UHHS perioperative data collected through each CSIS EMR undergoes source entry referential integrity checks to offer specific valid domain options through drop-down boxes, radio buttons, or check boxes. Default information from the GENOR, CVOR, HHOR, and ENDO schedules are pre-populated into data fields as default selections and edit checks can be performed across data fields when an EMR is submitted. However, not all valid options are correct. Furthermore, the perioperative EMRs listed in Table-2 occur at different times, in different locations, in different sequences. Hence the need for flexible logic control, due to numerous validation types across as many as six EMRs in sequence. As a result, UHPS developed data quality control checks (QCCs) as logic rules, which currently consists of 54 rules to monitor EMR completeness, context, time sequence, location, and surgeon specialty. Table-3 summarizes QCC rules by EMR type, error frequency, and type of data validation context.

An example of a QCC rule is below. The logic rule #2011 flags completed surgical cases with short or excessive OR cleanup times for exception review. Calculations on the OR cleanup time metric yield the intra-operative TAT (e.g., OR turn around time) KPI.

#2011 - If the total cleanup time (CLEANUP_STOP_DT_TM minus CLEANUP_START_DT_TM) is less than 5 minutes or greater than 60 minutes then flag record as inaccurate OR cleanup.

All data QCC rules listed in Table 3, stated similarly to #2011 above, are housed in a flexible dictionary file where rules can be added, modified, activated, or inactivated as needed. The QCC review ignores inactive rules.

Quality Control Check Review

Each morning a CSIS procedure applies the QCC review across all nursing EMRs of finalized (e.g., completed) surgical cases prior to moving finalized case nursing EMRs to the data mart. Surgical cases having an EMR violate any QCC rule become non-finalized and have the completed case flag turned off. All finalized case EMRs passing all QCC rules are then moved to the data mart. The QCC review procedure yields an exception report summarizing the number of finalized cases reviewed, the number of non-finalized cases retained, the number of unresolved flags from QCC rule exceptions, as well as an itemized list by MRN, encounter, case number, violated check ID, QCC rule, error comment field, and the nurse responsible for entering the nursing EMR. Figure 2 illustrates the CSIS embedded QCC review process flow and Table-4 is an excerpt of a reconciled non-finalized case exception report. The embedded QCC review procedure prevents any completed case becoming finalized until all QCC rules are met. Charge capture of CSIS EMRs only occur with finalized case EMRs as they move to the data mart.

Prior to October 2016, OR scheduling nurses

<table>
<thead>
<tr>
<th>EMR</th>
<th># Errors</th>
<th>Check IDs</th>
<th># of QCC Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACT</td>
<td>29%</td>
<td>1005</td>
<td>1- PACT diagnosis</td>
</tr>
<tr>
<td>PreOP</td>
<td>8%</td>
<td>102, 1001 to 1004, 1006</td>
<td>1- patient in PreOP, 4- PreOP time sequence, 1- PreOP nurse ID</td>
</tr>
<tr>
<td>OR</td>
<td>36%</td>
<td>103, 2001 to 2022, 5001, 5002</td>
<td>1- patient &amp; start in OR, 11- OR time sequence, 11- OR specific content, 2- overlap or - turn time</td>
</tr>
<tr>
<td>PACU</td>
<td>25%</td>
<td>104 to 106, 3001 to 3015</td>
<td>3- PACU completeness, 13- PACU time sequences, 2- PACU nurse/surgeon</td>
</tr>
<tr>
<td>All</td>
<td>2%</td>
<td>101, 107 to 109</td>
<td>1- case completeness, 3- key completeness</td>
</tr>
</tbody>
</table>

Table 3 – QCC Rules by EMR Type

![Image of QCC Rule Validation Flow]

Figure 2 –QCC Rule Validation Flow

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manually reconciled nursing EMRs of completed surgical cases. With the embedded QCC process, the OR
Analytics Director (i.e., one person) reconciles exception cases when nursing EMRs violate QCC rules and OR
scheduling nurses focus on facilitating OR scheduling improvement and CSIS training.

EMR Reconciliation

Table 4 – Non-finalized Case Exception Report Excerpt

The non-finalized case exception report depicted in Table 4 is reconciled daily where each QCC rule exception
is reviewed with nursing staff for resolution, the corrected nursing EMR data field information is obtained, and
the resolution for the specific QCC rule exception is noted. The reconciled non-finalized case exception reports
are archived in Microsoft SharePoint and the corrected EMR data field information is transferred to a Microsoft
Access database table for reprocessing. Microsoft Access is used to front-end Microsoft SQL Server where a
SQL procedure updates the CSIS with the corrected nursing EMR data field information by MRN, encounter,
and case number key as well as setting the completed case flag to on. The reconciled completed cases are then
ready for the embedded CSIS QCC review procedure to apply data QCC rules according to the CSIS processing
schedule or earlier on demand as needed. The QCC rules, embedded QCC review, and non-finalized EMR
exception reconciliation in combination support BPM by improving the data quality of perioperative nursing
EMRs and associated data.

The non-finalized case exception reports in aggregate offer UHPS an opportunity to
monitor and improve the data content of nursing EMRs. A wider horizon of review identifies where EMR data exceptions are occurring more frequently, within which perioperative sub-process, and by whom. Table 3 identified OR, PACT, and PACU respectively as having the largest percentage of total EMR data exceptions. Focusing on frequency and location allow targeting system changes to address EMR exceptions that yield the most impact, while focusing on who is entering the EMR exceptions directs additional training and control needs. Since October 2016, incomplete primary OR procedure description and OR turn time calculations represented 63% of QCC violations in OR documentation. PACT documentation lacking a valid PreOp diagnosis, PACU documentation lacking consistent primary surgeon notation, and PACU time sequencing between OR and PACU and within PACU (e.g., Phase II and ICU Overflow) were the highest QCC violations in PACT and PACU respectively.

In aggregate, Figure 3 depicts the number of surgical cases completed per month and the number of finalized cases (e.g., all EMRs correct) on first QCC review from October 2016 to January 2018. Figure 3 also identifies when QCC rules were added (e.g., November 2016, April 2017, May 2017, July 2017, and September 2017). Note how the trend lines between completed and finalized cases on first QCC review diverge. Figure 3 illustrates how the QCC review identified EMR data exceptions. Exceptions that undergo EMR reconciliation
and further QCC reviews. Non-finalized surgical cases are not considered complete (i.e., finalized) until further QCC reviews verify all EMR data exceptions have been reconciled. QCC rules, the embedded QCC review process, and non-finalized EMR exception reconciliation yield perioperative EMR data quality assurance and finalized surgical cases housed in the CSIS data mart for applications and data consumers downstream.

Conclusion

Empowered individuals, integrated IS, and an embedded QCC review within a BPM framework allows UHPS to ensure nursing EMRs within the CSIS meet data quality standards for: (1) patient care documentation, (2) patient billing, (3) perioperative data analysis, and (4) regulatory agency audits. No completed surgical case nursing EMR will capture patient charges or be moved for analytical analysis until all QCC rules are met. All exceptions to QCC rules are documented, reconciled, corrected, and nursing EMR training is directed as needed. Furthermore, the embedded QCC review is flexible to adjust to changes within the perioperative process as needed. Moreover, the BPM framework within the non-finalized case EMR reconciliation allows QCC process improvement opportunity as well as organizational learning. Data quality assurance within the CSIS data mart provides analytical opportunities to improve clinical effectiveness as well as process performance. Data quality assurance within the CSIS data mart encourages trust from knowledge workers and stakeholders within the perioperative process as well as applications and data consumers downstream. Likewise, data quality assurance in perioperative care documentation meets external regulatory requirements as well as mitigates audit risk. To this end, an embedded QCC process within integrated hospital information systems provides a solid foundation on which to develop and enhance BPM.

Our case study contributes to the healthcare IT literature by examining how flexible QCC rules, an embedded QCC review, and EMR reconciliation of QCC exceptions within a BPM framework is applicable to the hospital environment. This study prescribes an a priori framework to embed data quality assurance into perioperative patient care documentation and foster the occurrence. This research also answers the call by Lee et al. (2004) to embed continuous data quality improvement into the business processes. Additionally, this paper fills a gap in the literature by describing how hospital process data is both a performance measure, a management tool, and a valued resource.

This study was limited to a single case, where future research should broaden the focus to address this issue along with others that the authors may have inadvertently overlooked. The case examples presented in this study can serve as momentum for healthcare process management methodology, comprehension, and extension. The study’s results should be viewed as exploratory and in need of further confirmation. Researchers may choose to further or expand the investigation; while practitioners may apply the findings and create their own version of embedded data quality assurance within integrated hospital information systems.

References


