FEATURE ARTICLE

Operating Room Delays

Meaningful Use in Electronic Health Record

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Perioperative areas are the most costly to operate and account for more than 40% of expenses. The high costs prompted one organization to analyze surgical delays through a retrospective review of their new electronic health record. Electronic health records have made it easier to access and aggregate clinical data; 2123 operating room cases were analyzed. Implementing a new electronic health record system is complex; inaccurate data and poor implementation can introduce new problems. Validating the electronic health record development processes determines the ease of use and the user interface, specifically related to user compliance with the intent of the electronic health record development. The revalidation process after implementation determines if the intent of the design was fulfilled and data can be meaningfully used. In this organization, the data fields completed through automation provided quantifiable, meaningful data. However, data fields completed by staff that required subjective decision making resulted in incomplete data nearly 24% of the time. The ease of use was further complicated by 490 permutations (combinations of delay types and reasons) that were built into the electronic health record. Operating room delay themes emerged notwithstanding the significant complexity of the electronic health record build; however, improved accuracy could improve meaningful data collection and a more accurate root cause analysis of operating room delays. Accurate and meaningful use of data affords a more reliable approach in quality, safety, and cost-effective initiatives.

KEY WORDS: Data collection, Documentation, Electronic health record, Meaningful use, Operating room

It is estimated that 60% to 70% of all hospital admissions are due to surgical interventions and account for more than 40% of the total expenses of a hospital.[1] Costs are 2.5 times higher for hospital stays that involve an operating room (OR) procedure than stays that do not involve an OR procedure.[2] A healthcare organization's ORs are the most costly areas to run, making them a target for innovations intended to increase cost-effectiveness and productivity without sacrificing patient safety and quality of care.[3,4] Increasing operational costs, surgical delays, and other inefficiencies in the OR pose a barrier to optimal patient flow,[4–8] raise patient anxiety levels, affect interprofessional teamwork across medical disciplines, and ultimately place patients at risk.[3,5,6,9] The actual financial costs of surgical delay are difficult to determine due to varying factors such as administrative overhead, type of surgery, reasons for delay, and regional costs. An estimate of cost is about $20 per minute of delay; however, a more accurate accounting could be obtained by conducting a root cause analysis (RCA) for a specific organization's OR delays.[10]

Operating room delays are a primary cause of inefficiencies and wasted resources, and they strongly predict the system vulnerabilities (weaknesses and threats) of an organization. Ascertaining system vulnerabilities for surgical delays is a healthcare priority[7,10,11] and facilitates better understanding of surgical delays for efficient management and cost containment.[2,10,11] There is wide variation in the reported occurrence of OR delays, with rates ranging from 40% to 96% of all cases.[3,6,12] Surgical delays are often due to nonclinical reasons, with the most common reasons including no postoperative bed, staff nurses too busy to accept a patient, and staff meal breaks.[12,13] Other reasons for delays include unavailability of surgeon and anesthesiologist,[12] unprepared patients, inefficient and inaccurate scheduling,[1] and OR turnover time.[4]

This organization was concerned about their OR delays and authorized a project to use data from its electronic health record (EHR) to determine the root causes of the delays for future process improvement initiatives for quality, efficiency, and cost containment. The EHR was successfully implemented in July 2013, 1 year before implementation of this project. The EHR implementation included three hospitals, multiple hospital clinics, primary care and specialty community clinics, as well as services such as home health and hospice. The roll out was coordinated and well planned given the size and complexity of this healthcare system; it was a massive undertaking.

REVIEW OF THE LITERATURE

Meaningful data were needed to explore OR delays in this organization in order to recommend an evidence-based

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practice change and truly reflect quality of care; this requires complete and error-free clinical data abstraction from EHRs.[14] Electronic health records have made it easier to access and aggregate clinical data; however, the extracted data are not always useful and may lead to poor data integrity. The ability to extract needed information from the EHR presents a challenge for accurate data collection. Inaccurate data extraction further inhibits quality improvements and research.[15,16] The importance of meaningful data in an EHR has been emphasized by the Centers for Medicare & Medicaid Services (CMS) EHR Incentive Programs, which provide payments for achieving meaningful use (MU) health and efficiency goals by using EHR technology. Not all quality measures that an organization chooses to analyze may count as core measures under the incentivized MU program; however, an organization's strategic plan may follow the MU program to guide other organizational analytics for quality, safety, and efficiency.[17] Electronic health records have significant potential to improve patient care, quality outcomes, data extraction, and coding accuracy. This potential further demonstrates the importance of the EHR implementation. Implementing a new EHR system is complex; validating the EHR development and deployment processes determines the ease of use and user interface. Poor implementation can have severe unintended consequences; if not designed and used correctly, an EHR can produce inaccurate data[17,18] that inhibit efficient quality improvement projects.[15]

METHODS

Purpose

The primary goal of this project was to quantify OR delays in the organization and then to conduct an RCA of surgical delays by extracting retrospective EHR data.

Design

A quantitative and qualitative RCA design was used to identify the percentage of delays and system vulnerabilities (weaknesses or threats) that prevent surgical cases from starting on time. A retrospective EHR report was queried to include the following fields: case identification (ID), service, location, first case, surgery date, scheduled start time, actual start time, delay length, delay type, delay reason, and delay comments. The report was requested for this project and was developed by the organization. The report was then converted into a sortable Excel spreadsheet (Microsoft, Redmond, WA); the abstraction was considered complete without changing fields or adding to missing or incomplete data. Additionally, a 2-hour validation session was held with eight OR personnel (two nurse anesthetists, a nurse manager, three preoperative [preop] nurses, and two circulating nurses) to report initial findings and elicit their responses to the findings. The organization defined delays as any case that starts 1 minute or more after the scheduled start time. For cases that were delayed, an OR staff member was to select and enter a delay type (facility, anesthesia, staff, patient, physician/surgeon, or other) in the EHR and then scroll through 69 delay reasons to select one reason. A final free text entry was allowed for comments regarding the delay.

Setting

The setting was an academic tertiary care center in the Southeastern United States. Two OR settings were identified for this project as they shared leadership, staff, and workflows. Other freestanding OR settings not located in the main hospital were not included. The annual average number of surgical cases in the two selected ORs was approximately 4000.

Sample

The sample included all scheduled surgical cases over a 6-month period between July and December 2014. The EHR original sample size was 2541 cases; however, following data cleaning, there were 2123 valid cases. Cases included were 822 actual start time without delay and 1301 actual start time with delay. Cases excluded were two cases with delay length outliers greater than 30% than next delayed case and 402 duplicate case IDs. A convenience sample of OR personnel participated in a validation session to provide insight into the initial findings of the EHR review.

Data Analysis

Quantitative analysis included both objective (data that were time stamped or required no decision making) and subjective (the recorder had to select a delay type and delay reason) data from EHR fields. Descriptive statistics were used to report percentage of delay cases and delay length overall and by first case and subsequent cases. Descriptive statistics were also used to report delay type, delay reason, and service. Qualitative analysis included the clinical team validation session held with OR personnel to glean insight from the quantitative subjective data (delay type and delay reason) and the free text notes entered into the delay comments field of the EHR.

This study was approved by the organization's institutional review board.

RESULTS

Quantitative Analysis of Objective Data

The quantitative analysis of objective data showed verifiable outcomes of OR delay length overall and by first and subsequent cases. Overall, 61.2% of all cases were delayed; the delay rate for the first case was 27.2%, and the subsequent case delay rate was 72.8% (Table 1). Of the 2123 surgical cases, 1301 cases were delayed ranging between 1 and 367 minutes. To better understand the data, the delays were placed into 15-minute incremental bins; beyond the 300-minute bin,

Table 1. Quantitative Analysis of Objective Data

Delay Length					
Overall Delays (n = 1301)		**First Case Delays (n = 354)**		**Subsequent Case Delays (n = 947)**	
Mean	56.97	Mean	18.65	Mean	71.29
Median	36	Median	11	Median	55
Mode	7	Mode	2	Mode	7
SD	59.40	SD	31.40	SD	61.04
Minimum	1	Minimum	1	Minimum	1
Maximum	367	Maximum	283	Maximum	367
Confidence level (95.0%)	3.23	Confidence level (95.0%)	3.28	Confidence level (95.0%)	3.89
Overall delay	61.20%	First case delay	27.2%	Subsequent case delay	72.80%

there was only one case in each bin. Nearly 30% of all delay length was 15 minutes or less and 78% was 90 minutes or less. Furthermore, the EHR provided meaningful data related to service and delay length. Services with higher case volume had more delays and had an overall greater impact on delay length than did services that had a smaller case volume despite having a longer mean delay. When the organization focuses their efforts on process improvement, the quantitative analysis of the objective data provides direction of some areas to target for improvement.

Quantitative Analysis of Subjective Data (Delay Type, Delay Reason, and Permutations)

The EHR provides the recorder the option to select one of six delay types and one of 69 delay reasons. There were no required-entry quality checks (known as hard-stops) to ensure that either a delay type or a delay reason was selected, and thus, missing data were also possible. This results in 414 (6 × 69) available permutations built into the EHR, plus unreported (missing) data for both delay type and delay reason, resulting in 490 (7 × 70) possible permutations (combinations of delay type and delay reason). Of these, 132 permutations were entered between July and December 2014 (Table 2). Through further analysis, it was found that nearly all of the delay reasons had a delay type embedded. Despite the redundant appearance, the delay reason was often categorized under several delay types as evidenced by the number of permutations. For example, noted in Table 2 under delay reason, "anesthesia—additional labs, tests, etc.", had been categorized under five different delay types, resulting in five different delay permutations. Even though the embedded delay reason provides a type, such as anesthesia, staff had additionally categorized the delay reason under patient, staff, other, and unreported (missing). Additionally, the same language was not used between delay type and delay reason, which further complicated the inconsistency in classification for OR delays and inhibited accurate analysis. Under delay type, the word *facility* was used, and under delay reason, *hospital* was used; incongruent language was used again for staff under delay type and nurse under delay reason. Another inconsistency was five delay reasons that did not have a current delay type embedded. Other and missing data were categorized in all delay types.

Furthermore, delay frequency (Table 3) demonstrated the most frequently reported reason for delays, which matched the most frequently reported permutations; however, the picture was not as accurate as it could have been. The most frequently reported reason for delay was other (15.1%), and when combined with missing data (8.4%), they accounted for nearly 24% of delays, which provided no meaningful data. The analytic picture was further diluted by the number of possible permutations (delay type and reason combined) as the most frequently reported types, reasons, and permutations (Table 3) comprised a small representation of the available options. During the 6-month period, there were only 12 delay reasons and 11 permutations that had more than 30 cases. Additionally, 46 delay reasons were entered fewer than 10 times, and seven delay reasons were not used at all.

When analyzing the trends for the delay comment field for delayed cases, approximately 47% of delay comments could be categorized into a current delay reason that had been marked other or was otherwise unreported "missing" data. (Other was entered in 196 cases, although 59% of the cases could have been categorized, and missing was entered in 109 cases, although 43% of the cases could have been categorized.) Additionally, approximately 5% of delay comment field was used for nursing communication rather than a delay reason. In 5% of the delayed cases, no delay comment or delay reason was chosen and it was unclear as to why there had been an OR delay. Themes that started to emerge from delay comments categorized as "other" that could not be re-categorized into a useful delay reason included no history and physical, needs pain medication or pain prescriptions, waiting on anesthesia sign-out, and acuity or unstable patient.

Additionally, it was discovered that delay type, delay reason, and delay comments were not solely used for OR delays; these fields were used in the absence of delays as well. They

Table 2. Quantitative Analysis of Subjective Data

Delay Type	Delay Reason	Permutations[a]
Anesthesia	Anesthesia—additional labs, tests, etc	5
	Anesthesia—block/epidural in holding area	2
	Anesthesia—difficult airway	2
	Anesthesia—difficult block/spinal	2
	Anesthesia—equipment/set up	2
	Anesthesia—extended time to PACU/ICU	2
	Anesthesia—failed block	1
	Anesthesia—insufficient coverage	1
	Anesthesia—IV access	2
	Anesthesia—late to OR—faculty	1
	Anesthesia—late to OR—provider	1
	Anesthesia—preop needed longer to work	3
	Anesthesia—preop visit	1
	Anesthesia—prolonged emergence from anesthetic	2
	Anesthesia—with another patient	5
Facility	Hospital—blood delay	0
	Hospital—case added to room	2
	Hospital—emergency case added to room	3
	Hospital—emergency case in room	2
	Hospital—financial clearance	1
	Hospital—hold for ER case	1
	Hospital—housekeeping delay	2
	Hospital—interpreter needed	2
	Hospital—no bed available—postop	2
	Hospital—no bed available—preop	1
	Hospital—no unit bed available	2
	Hospital—OR housekeeping delay	0
	Hospital—pager system not working	1
	Hospital—pharmacy delay	1
	Hospital—previous case cancelled	2
	Hospital—radiology tech not available	2
	Hospital—recovery room closed	0
	Hospital—transport not available	4
	Hospital—x-rays not available	2
Staff	Nurse—no preop evaluation	1
	Nurse—not available	3
	Nurse—OR suite did not send for patient	1
	Nurse—patient not ready—day surgery	2
	Nurse—patient not ready—ER	0
	Nurse—patient not ready—floor/ICU	3
	Nurse—room set-up	2
Patient	Patient—delay—talk to surgeon	2
	Patient—difficult positioning	1
	Patient—late arriving to hospital	1
	Patient—left area	1
	Patient—not NPO	1
	Patient—wait for family members/ parents	2
Physician/ surgeon	Surgeon—additional labs, x-rays, etc, needed	3
	Surgeon—cancelled case	0
	Surgeon—change order of cases	2
	Surgeon—incomplete or no consent	3
	Surgeon—incomplete scheduled information	1
	Surgeon—late to OR—faculty	2
	Surgeon—late to OR—resident	1
	Surgeon—previous case ran over	3
	Surgeon—Pt not marked	1
	Surgeon—took longer than posted	4
	Surgeon—undictated hold	1
	Surgeon—unscheduled procedure added to case	2
	Surgeon—with another patient	3
	Surgeon—work-up on arrival	1
Uncategorized	Abnormal lab values	1
	Equipment—being used in another room (comment required)	1
	Equipment—malfunction (comment required)	2
	Equipment—not available (comment required)	3
	Instrument/implant—not available (comment required)	2
Other	Other	7
Missing	Unreported (missing) Data	7

(continues)

Table 2. Quantitative Analysis of Subjective Data, Continued

Abbreviations: ER, emergency room; ICU, intensive care unit; IV, intravenous; NPO, Nil per os.

[a]Permutation is a combination of delay type and delay reason.

appear to be used for any concern during transition of care throughout the OR process (preop, OR, postanesthesia care unit [PACU], and/or the disposition home or inpatient). Of the 822 cases without surgical delays, 97.6% had a delay type, 91.6% had a delay reason, and 67.2% had a delay comment. These results confirmed the inconsistent methodology for classification and use of EHR fields for purposes other than their intended design.

While this hindered the ability to discern the root cause for delays, it yielded many other valuable insights. The data insights were brought to a clinical team validation session to provide information and substantiate findings, and to glean an understanding of how delay type and delay reasons, specifically other and unreported (missing) data, were chosen. Participants included OR management, anesthetists, circulator, and preop staff.

During the validation session, it was noted that anyone with access to the surgical case could complete the data entry

Table 3. Summary Analysis

Summary: Most Frequently Reported								
Delay Types			**Delay Reasons**			**Permutations[a]**		
	Case	**%**		**Case**	**%**		**Case**	**%**
Facility	325	25.0%	Other	196	15.1%	Facility/hospital—no bed available postop	174	13.4%
Physician/surgeon	325	25.0%	Hospital—no bed available postop	185	14.2%	Staff/nurse—not available	109	8.4%
Other/missing	202	15.5%	Nurse—not available	115	8.8%	Physician/surgeon/surgeon—incomplete or no consent	83	6.4%
Staff	188	14.5%	Missing	109	8.4%	Other/other	71	5.5%
			Surgeon—incomplete or no consent	85	6.5%	Physician/surgeon/surgeon—with another patient	59	4.5%
			Surgeon—with another patient	64	4.9%	Facility/hospital—no unit bed available	53	4.1%
			Hospital—no unit bed available	54	4.2%	Physician/surgeon/surgeon—late to OR—faculty	47	3.6%
			Surgeon-Late to OR-Faculty	49	3.8%	Anesthesia/anesthesia—block/epidural in holding area	45	3.5%
			Surgeon—previous case ran over	47	3.6%	Patient/other	38	2.9%
			Anesthesia—block/epidural in holding area	46	3.5%	Physician/surgeon/surgeon—previous case ran over	34	2.6%
			Hospital—transport not available	40	3.1%	Physician/surgeon/other	30	2.3%
			Anesthesia—with another patient	35	2.7%			
Total = 6 types; all used plus missing		80%	Total = 69 reasons; 57 used plus missing		79%	Total = 490 permutations; 132 used including missing		57%

[a]Permutation is a combination of delay type and delay reason.

fields anytime during the process; this was demonstrated through 402 duplicate cases that had multiple delay types and delay reasons. The duplication rate was nearly 16%; cases were duplicated as many as four times. The validation team confirmed that there was no standardized process around entering delay type and delay reason into EHR fields and no standardized process for who was responsible for entering delay type and delay reason. There appeared to be a lack of understanding and knowledge on staff's part on the importance of accurate EHR field data entry, and since there were no hard-stops, required entry of data, missing or other were frequently used. Additionally, they were used as shortcuts to bypass sorting through the numerous fields; the six delay types and 69 delay reasons were too numerous to sort through when staff were in a hurry. Overall, this led to inconsistent methodology for classification.

Further findings during the validation session included lack of sufficient education. The team was unaware of the significance of the meaningful data and the need for accurate EHR field completion for analysis. The team was also unaware of the number of possible delay type/reason permutations available for OR delays. The team stated there was limited education on the selection process for delay type or delay reason and in hindsight they confirmed how it contributed to the inconsistent classification system.

DISCUSSION

This organization's OR delays were consistent with national averages, both in the frequency as well as the reported cause of delays. However, identifying factors and trends was challenging due to the quality of the subjective quantitative data and the classification system (number of delay types, reasons, and ultimately, permutations). The most frequently reported reason and permutations were consistent with published data; however, if the process for entering the delay type and reason fields was simplified with less other or missing data, a more accurate analysis might emerge, contributing to more MU. The challenge with excessive number of delay reasons is accurate data collection and ease of use.

The ease of use issue was further evidenced by objective versus subjective quantitative data. The objective quantitative data in EHR fields that were automatically generated (case ID, surgery date, scheduled start time, case scheduled end, and service) through the scheduling process or time stamped (actual start time and actual end time), which required no decision making, resulted in straightforward analysis for MU. Through descriptive statistics, delay length mean and frequency were determined. The difference between first case delays, subsequent case delays, and the relationship to overall case delays was quantifiable. It was determined that 30% of all case delays occur within the first 15 minutes and 78% of all case delays were under 90 minutes. The literature review confirmed that the cost of OR delays to an organization are not only financial but also impact quality, safety, and efficiency.

The next step in the process was to determine, through meaningful data collection and analysis, the cause of delays, and from there to initiate process improvements. This was consistent with the motivation provided by the CMS EHR Incentive Programs to achieve MU by using EHR technology to achieve health and efficiency goals. However, the process of quantitative subjective data entry and interpretation (delay type and delay reason) was flawed and prevented the capture of a complete, accurate picture. Additionally, the use of the delay comment section, other, and unreported (missing) data further diluted the picture of the most frequently occurring root causes for OR delays. Before the clinical focus of patient flow and OR efficiency can be managed, the EHR process needs to match the intent of the design for ease of use and collecting accurate, meaningful data. With the number of possible permutations, an accurate and reflective RCA cannot be achieved, most likely due to staff feeling overwhelmed, using work-arounds, and having a lack of understanding or knowledge regarding the intent of the EHR design and need for meaningful data. It appeared as if there was not a standardized process for choosing delay type or delay reason. There were no hard-stops to ensure that these data fields were completed, nor was there a standardized process for the responsibility to complete the data fields or the location for the delays (preop, OR, PACU, or disposition). It was believed that this had been addressed in design, but as in many EHR designs, the challenges are unknown until the system is fully operational.[18]

The most frequently reported reasons for OR delays (noted in Table 3) are a starting point for the organization to focus their efforts in reducing the number of delay reasons. However, until the EHR design facilitates the intent of the process, the organization will not know with certainty what other issues may surface, as it would if the process were streamlined for ease of use.

Implications for Future Use

The organization engaged in an enormous undertaking implementing an EHR in three hospitals, multiple clinics, and physician offices; they did an outstanding job given the size and complexity of the project. The organization performed initial validation sessions prior to the EHR "go-live" dates; however, in large implementation projects such as this, it would be beneficial for organizations to perform intermittent postimplementation validation sessions to determine if the vision of the implementation matched the intent of the EHR design. Validation sessions are opportunities to discover work-arounds and to realign frontline staff in selecting correct data fields to ensure that meaningful data are being collected. The next steps to further this project would be to revalidate the intent of the EHR design and address issues identified in the validation session. This would include paring down 69 delay reasons or having specific reasons open through a drop-down box that pertain only to the delay type (ie, when choosing facility, only facility-related reasons could be chosen and not reasons pertaining to the surgeon). More accurate data will surface by standardizing the process for choosing delay type and reason, implementing required-entry data fields (ie, hard stops), and using each field for its intended design. Additionally, to obtain more accurate information on overall delays, a location field could be added to better understand where the delay actually occurred (delay to preop, OR, PACU, or disposition). This level of data collection could provide the organization a more complete picture of the vulnerabilities for each stage in the operative process as well as provide more MU. After the EHR design matches the intent, an education process for staff on expectations for selecting delay data fields (location, type, and reason) as well as the need for meaningful (complete and accurate) data should be conducted.

Limitations

This analysis was conducted in one organization and their implementation of a particular EHR product with a standard design for delay fields.

CONCLUSION

Implementing a new EHR system is challenging and complex. To have true MU and analytic abilities, the validation and revalidation process is extremely important. The validation process assists in determining whether the intent of the design was fulfilled. When the intent of the design is not fulfilled, then it is a priority to refine and remeasure its usefulness. In this retrospective review, there was a lack of a standardized process for entering data, which affected the ability to retrieve meaningful data. This may be due to a lack of built-in edit checks, or hard-stops, to facilitate accurate data entry and prevent missing or unreported data. The fields were not always used for their intended design and the number of choices affected ease of use.

Nationally, EHR systems are not being used to their full capacity to facilitate organizations' accurate data analysis for research,[14] and there are significant concerns about the quality of EHR data as not being recorded at the same level of detail as research data collection.[15] The question now posed is, have EHRs led to an increased amount of bad data instead of the improvement of quality data collection? Due to the highly variable quality, EHR extracted clinical data are viewed as questionable for research purposes; the same may be posed for internal quality improvement, with the wide variation in measurement, recording, and clinical focus.[15] The potential for EHRs to create and share new knowledge and practice innovation through quality improvement and research is enormous; however, the lack of a standardized process, inaccuracy, and incomplete records are standing in the way. The challenges with EHR data entry and extraction inhibit the ability to retrieve needed information to improve quality and outcomes. Massive amounts of clinical data are being captured, and now, it is a matter of transforming and translating the data into meaningful data that can improve practice.[16]

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