Surgical mortality review reduces preventable deaths and patient safety indicators (PSIs)

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Abstract

Financial penalty for unacceptable rates of mortality and Patient Safety Indicators (PSIs) is the reality of external quality management. Review of hospital deaths have shown a decrease in mortality ratios, but there are little data evaluating the long-term viability and results of these programs. Methods: From 1/2013 through 8/2014, 26,699 inpatients were cared for on 12 surgical services. A surgeon from each service led reviews of all mortality and PSIs with central reporting of preventability. We compared the proportion of preventable mortality, PSIs and the UHC Observed to Expected Mortality ratio (O:E ratio) over time. Statistical significance was $p<0.05$ by Poisson regression. Results: Of the 26,699 inpatients in the study period, there were 510 deaths (1.9%) and 553 PSIs (2%) reviewed. Of the 510 deaths, 137 were categorized as possibly preventable or preventable. The odds ratio of a preventable mortality was half in the final quarter compared to the first quarter and this reduction was primarily seen in high-risk services ($p<0.05$). The proportion of preventable PSIs fell from 70% to 26% during the same time period ($p<0.05$). The O:E ratio was consistently below 1(less deaths than expected) and fell throughout the study period ($p<0.05$). Conclusions: The improvement in the O:E ratio previously seen with hospital mortality review is a sustainable process. With a long-term commitment, the additional benefits are a reduction in preventable mortality and PSIs, especially in high-risk services. This process is one component that improves outcomes and reduces patient mortality.

Introduction

Improving patient care outcomes is an important goal, as it affects not only patient health but also reimbursement. One focus of improving patient care is through Patient Safety Indicators (PSIs). PSIs were developed by the Agency for Healthcare Research and Quality (AHRQ) as a measured outcome for identification of complications, system failures, and system quality with the goal to help health care organizations improve delivery of care[1]. While initially designed as a screening tool for quality of care received at a hospital, they are now primarily used to modify reimbursement.

Another focus of improving patient care is determining cause of preventable deaths. Approximately 98,000 preventable deaths occur yearly[2] and authors have advocated various strategies to reduce this. Clarke et al advocated for a structured format in morbidity review in order to successfully determine root cause of adverse events[3]. Gupta et al advocated for committee based morbidity review over provider-based review, as provider-based review did not always correlate with committee-based conclusions[4]. Lau et al advocated for a multidisciplinary mortality review in order to trend data and establish patterns of harm[5]. Our previous study combined these concepts and created a structured, surgeon led committee of morbidity and mortality review that trended data to establish patterns of harm within the system[6]. The review process deviated from the traditional weekly to monthly divisional morbidity and mortality review and utilized a surgeon led committee spanning all divisions of the Department of Surgery at a large academic institution. It proved observed to expected (O:E) ratios decreased after the implementation of the new hospital-wide morbidity and mortality review system. However, the study was short term and did not identify the system failures causing mortality. The goal of this study was to evaluate the long-term viability of the surgeon led, committee based, hospital wide morbidity and mortality review and to determine results of the program. Specific identifiers of outcome included patient safety indicators (PSIs), hospital acquired complications (HACs), and O:E ratio changes.

Methods

A single-institution prospective study was conducted between January 2013 and August 2014 on patients undergoing an inpatient procedure across 12 surgical divisions. Following discharge, a surgeon from each division met as part of the Surgical Quality group to assess encounters and preventability of post-operative complications and mortality. Follow-up data was collected on patients regarding post-operative mortality, patient safety indicators (PSIs), and hospital acquired complications (HACs). Surgical divisions that made up the analysis within the department of surgery included burns, cardiovascular, gastrointestinal, neurosurgery, orthopedic, otolaryngology, plastic, surgical oncology, thoracic, transplant, trauma, urology, and vascular.

Data

The post-operative events of interest were death, PSIs, and HACs. These were recorded for each division. Administrative lists were developed that included any patient admitted to or discharged from each division to account for transfers to and from other services during their hospital stay. This was done to allow review for patients that received any care by a surgical division during their stay. Once identified administratively, clinical service reports (CSRs) were generated that compiled all diagnoses and procedures received during the course of the hospital stay. Patient lists with CSRs were generated 2 weeks after the end of each month and distributed to each division for presentation at morbidity and mortality meetings. The divisional/departmental representative to the Surgical Quality group was responsible for attending quarterly quality group meetings and ensuring distribution of the CSR, as well as presentation of the deaths, PSIs, or HACs that were accrued through the hospital database at a minimum of a monthly basis. Data was compiled at the DOS morbidity and mortality conferences and then sent to a central reporting group and entered into a prospective database.

Additionally, preventability (not preventable, possibly preventable, or preventable) of post-operative events and the root cause of each were discussed and recorded at these quality group meetings. Root causes included failure to escalate, failure to follow protocol, inadequate preoperative optimization, judgment, patient risk factors, supervision, and technical reasons. Further details of the proceedings of these meeting and the process of determining preventability and root causes were outlined in a previous study[6].

UHC comparative data was used to ascertain observed-to-expected (O:E) mortality ratio. This is calculated based on the actual deaths in a population, divided by the arithmetic sum of each individual patient's risk of dying (between 0 and 1) in that same population during the same time period. Risk of death is measured based on documented conditions at time of admission as well as those developed during the hospital stay.

Analysis

The main outcomes of interest were post-operative deaths, PSIs, and HACs, in addition to the event's preventability (not preventable, possibly preventable, or preventable). Root causes were collected for preventable or possibly preventable outcomes.

Patients who experienced outcomes of interest were described using univariate statistics and stratified by outcome to assess for differences among this subpopulation. Additional bivariate statistics were employed to examine differences in preventability within each outcome of interest. Chi-square statistics were calculated to measure for statistically significant differences among categorical variables. Wilcoxon signed-rank test was used to measure for statistically significant differences among continuous variables. Statistical significance for the O:E ratio was calculated using Poisson and logistic regression. All statistical thresholds for significance were set at an alpha (α) of 0.05.

Results

A total of 26,699 inpatient encounters occurred across 12 divisions of the DOS between January 2013 and August 2014. During the time of study 1,176 post-operative adverse events were observed; 534 deaths (2.0%), 578 PSIs (2.2%), and 64 HACs (0.2%). Characteristics of these outcomes for each patient encounter can be observed in Table 1, stratified by outcome of interest. Overall, the median age of patients observed was 60 years (IQR: 48-71), median length of stay (LOS) 11 days (IQR: 5-24), and procedures were predominantly emergent in status (53.8%). Trauma (22.7%) and Neurosurgery (13.9%) were the divisions to show the greatest proportion of adverse outcomes, with the lowest accounted for were from Plastic (1.0%) and Thoracic (2.7%). The majority of all adverse events were observed among divisions who primarily handle the most acute patient load of the DOS with 75.8% of all events occurring among Burns/Trauma, Cardiovascular, Gastrointestinal, Neurosurgery, Orthopedic, and Transplant.

Significant differences were observed across the three outcomes of interest: death, PSIs, and HACs. Those who experienced death were significantly older (61.5) and had a greater rate of emergent status (64.4%), p<0.0001. For patients who experienced an adverse outcome, a significantly higher proportion of PSIs were observed in the divisions of Gastrointestinal (69.4%), Orthopedic (64.3%), Otolaryngology (63.6%), Plastic (91.7%), Surgical Oncology (62.1%), and Urology (77.4%) when compared to other outcomes. A significantly greater median length of stay was observed among those patients experiencing a HAC (35, IQR: 11-79), p<0.0001.

For mortality outcome, a greater number of those events were classified as not preventable (72.8%), which can be observed in Table 2. Additionally, a significant association between admission status and mortality is shown, with a large proportion of death occurring among non-elective procedures (86.7%). Preventability in mortality varied greatly across admission status as a whole, however elective procedures showed a greater proportion of possibly preventable or preventable deaths when compared to urgent and emergent procedures. These were, respectively, 74.7% compared to 40.3% and 17.1%. When examining the root causes of these deaths, “failure to escalate” was largely identified as the etiology (38.4%), as evidenced in Figure 1.

Unlike mortality many of the outcomes were determined to be either preventable or possibly preventable (70.4%), in comparison to being not preventable (29.6%). Similar admission characteristics were found among PSIs as were found with mortality after stratification, with 56.7% of PSIs admitted as an elective status. However, there was no significant association found with admission status and PSIs (p=0.11). In addition, for PSIs “failure to follow protocol” (39.0%) was second the most common etiology, second only to those root causes classified as “missing”.

The analysis of HACs was both limited by small numbers (N=43) and missing preventability data (N=21), thus leading to a reduced ability to detect a true statistical association. Ultimately HACs were primarily emergent or urgent (72.1%) and categorized as preventable or possible preventable (86.0%).

Figure 2 presents the change in the preventability of deaths and PSIs over the course of the study period from the first quarter of 2013 through the third quarter of 2014. The figure demonstrates a significant decrease in the percentage of events among the entire surgery population during that quarter for both mortality and PSIs. Specifically, overall change in mortality and PSIs were found with a statistically significant (p<0.05) decrease from 75% to 28% and 39% to 18%, respectively. The most considerable decreases for mortality occurred between the fourth quarter of 2013 to the third quarter of 2014. For PSIs, there was a major decrease between the first and second quarter of 2013, followed by an increase during the third quarter of 2013 and a gradual taper over the remainder of the study period.

The graph in Figure 3 represents the long-term change in O:E mortality ratio over the length of the previous and current study periods by yearly quarter. The graph represents an overall decline in the O:E ratio, with the largest decline noted after the change in morbidity and mortality review process. Figure 4 highlights the change in O:E mortality ratio during the current study only. There overall was a decline in the OE ratio when comparing the first to last quarters of study. There was a statistically significant decrease in the O:E ratio after the second and fourth quarters of 2013 (p<0.05). Figure 5 demonstrates the change in absolute mortality over the course of study, including data from the previous and current studies. While no statistically significant difference in absolute mortality was identified, a clinically

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significant decrease was present with the number of absolute mortalities decreasing from 100 to 76.

Table 1. Patient Characteristics by Outcome of Interest

			Death		PSI		HAC		
	N	**Overall %**	**N**	**%**	**N**	**%**	**N**	**%**	**p-value**
Overall	**1176**		**534**	**(45.4)**	**578**	**(49.2)**	**64**	**(5.4)**	
Age†	60	(48-71)	61.5	(51-74)	59	(48-69)	53	(33.5-64)	<0.0001
Admission Type									
Elective	418	(35.7)	71	(17.0)	333	(79.7)	14	(3.4)	<0.0001
Urgent	123	(10.5)	57	(46.3)	57	(46.3)	9	(7.3)	
Emergency	629	(53.8)	405	(64.4)	183	(29.1)	41	(6.5)	
Surgical Division									
Burns	51	(4.3)	35	(68.6)	12	(23.5)	4	(7.8)	<0.0001
Cardiovascular	117	(9.9)	67	(57.3)	46	(39.3)	4	(3.4)	
Gastrointestinal	111	(9.4)	26	(23.4)	77	(69.4)	8	(7.2)	
Neurosurgery	164	(13.9)	93	(56.7)	66	(40.2)	5	(3.1)	
Orthopedic	70	(5.9)	16	(22.9)	45	(64.3)	9	(12.9)	
Otolaryngology	44	(3.7)	14	(31.8)	28	(63.6)	2	(4.6)	
Plastic	12	(1.0)	1	(8.3)	11	(91.7)	0	(0.0)	
Surgical Oncology	58	(4.9)	18	(31.0)	36	(62.1)	4	(6.9)	
Thoracic	32	(2.7)	14	(43.8)	18	(56.3)	0	(0.0)	
Transplant	110	(9.3)	42	(38.2)	64	(58.2)	4	(3.6)	
Trauma	268	(22.7)	164	(61.2)	85	(31.7)	19	(7.1)	
Urology	53	(4.5)	11	(20.8)	41	(77.4)	1	(1.9)	
Vascular	89	(7.6)	33	(38.4)	49	(57.0)	4	(4.7)	
Length of Stay†	11	(5-24)	6	(2-14)	14	(8-29)	35	(11-79)	<0.0001

† Median and Interquartile Range (IQR)

Table 2. Preventability of Mortality

			Not Preventable		Possibly Preventable		Preventable		
	N	**Overall %**	**N**	**%**	**N**	**%**	**N**	**%**	**p-value**
Overall	**533**		**388**	**(72.8)**	**128**	**(24.0)**	**17**	**(3.2)**	
Admission Type									
Elective	71	(13.3)	18	(25.4)	44	(62.0)	9	(12.7)	
Urgent	57	(10.7)	34	(59.7)	21	(36.8)	2	(3.5)	<0.0001
Emergency	405	(76.0)	336	(83.0)	63	(15.6)	6	(1.5)	

Table 3. Preventability of PSI

			Not Preventable		Possibly Preventable		Preventable		
	N	**Overall %**	**N**	**%**	**N**	**%**	**N**	**%**	**p-value**
Overall	**466**		**138**	**(29.6)**	**273**	**(58.6)**	**55**	**(11.8)**	
Admission Type									
Elective	264	(56.7)	70	(26.5)	162	(61.4)	32	(12.1)	
Urgent	54	(11.6)	14	(25.9)	30	(55.6)	10	(18.5)	0.11
Emergency	148	(31.8)	54	(36.5)	81	(54.7)	13	(8.8)	

Figure 1. Reasons for Preventable Mortality/PSI. Y-axis represents percentage of events and X-axis represents reason for events.

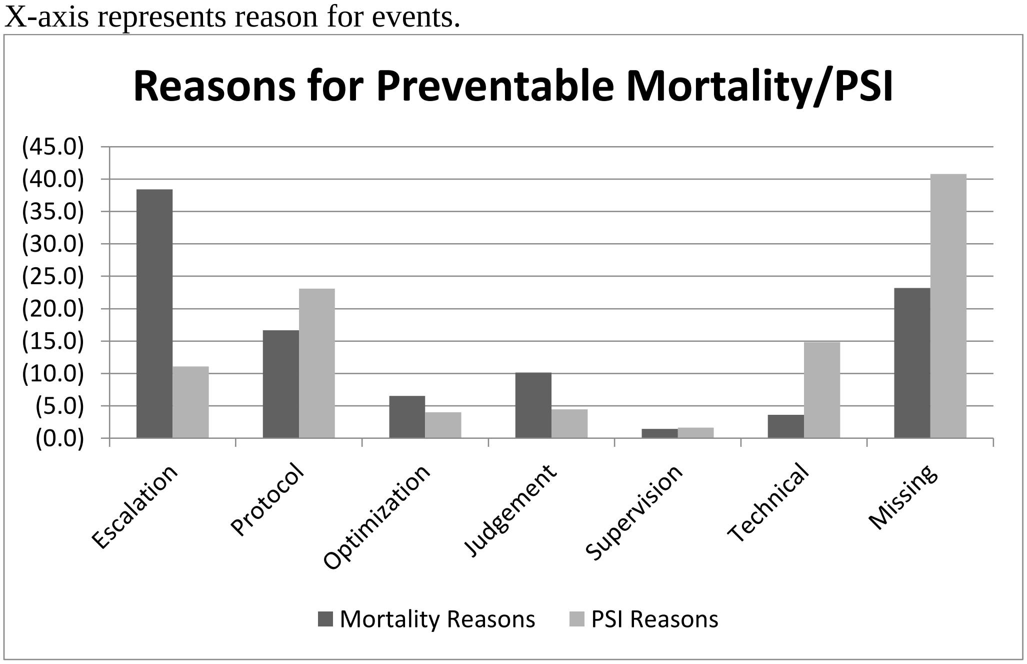


Figure 2. Overall change in preventable events. Y-axis represents percent of events throughout the course of study. X-axis represents progression of quarters throughout the course of study. Statistical significance was defined by p<0.05 by Poisson regression. CY, calendar year; Q, quarter.

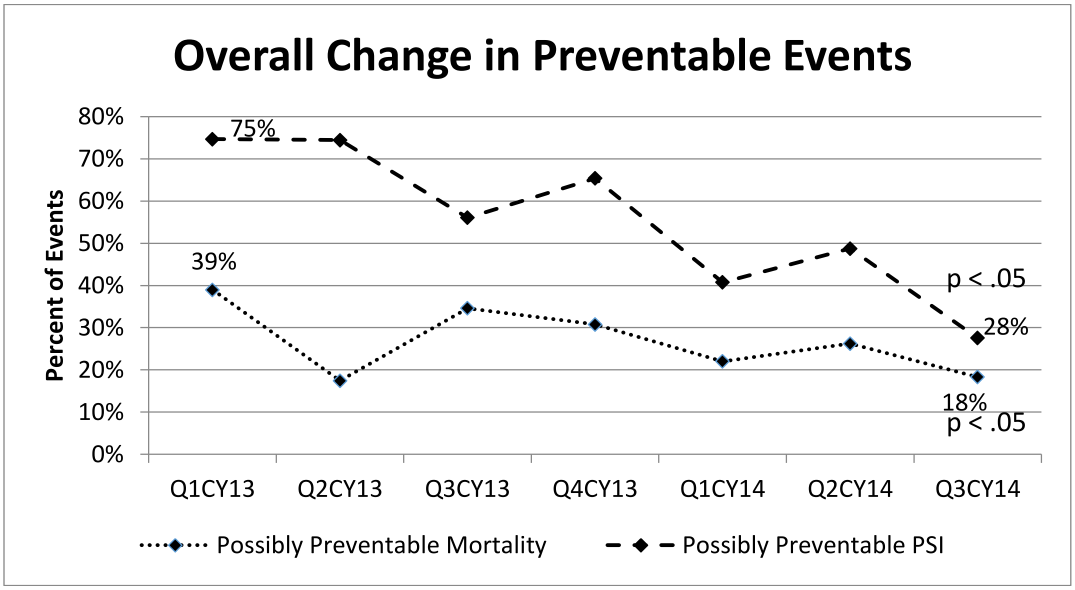


Figure 3. Long-term Change in O:E Mortality Ratio. Y-axis represents O:E ratio and X-axis represents progression of quarters throughout the current and previous study. Data in the first portion of the graph represents historical data. Data in the mid-portion of the graph represents data from the previous study. Data in the last portion of the graph represents data from the current study. Greater than 1.0 means more patients died than expected; Less than 1.0 means less patients died than expected. Statistical significance was defined as p<0.05 by Poisson regression. Q, quarter.

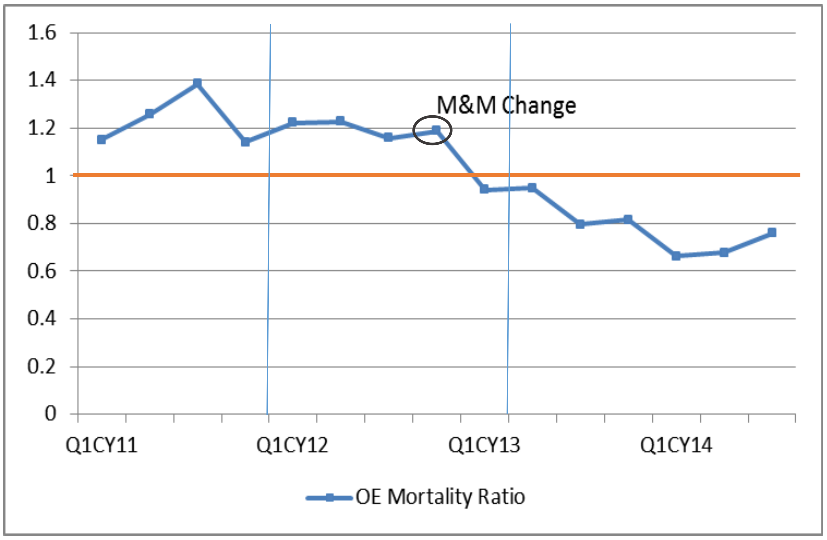


Figure 4. Change in O:E Mortality Ratio. Y-axis represents O:E ratio and X-axis represents progression of quarters throughout the course of study. Greater than 1.0 means more patients died than expected; Less than 1.0 means less patients died than expected. Statistical significance was defined as p<0.05 by Poisson regression. Q, quarter.

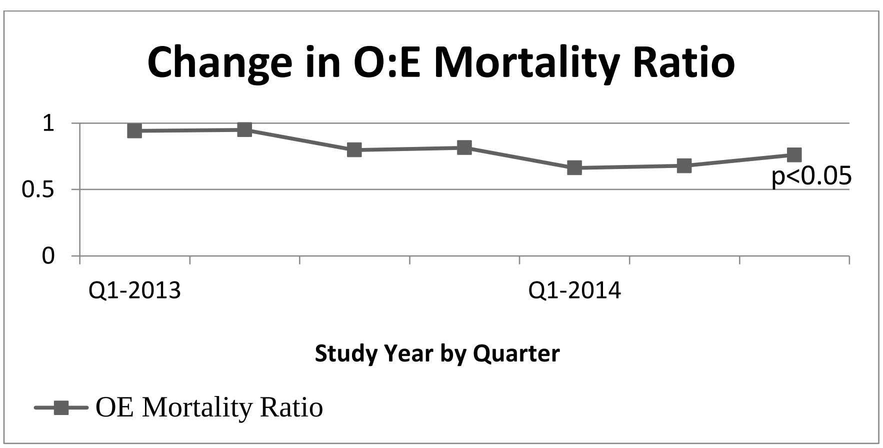
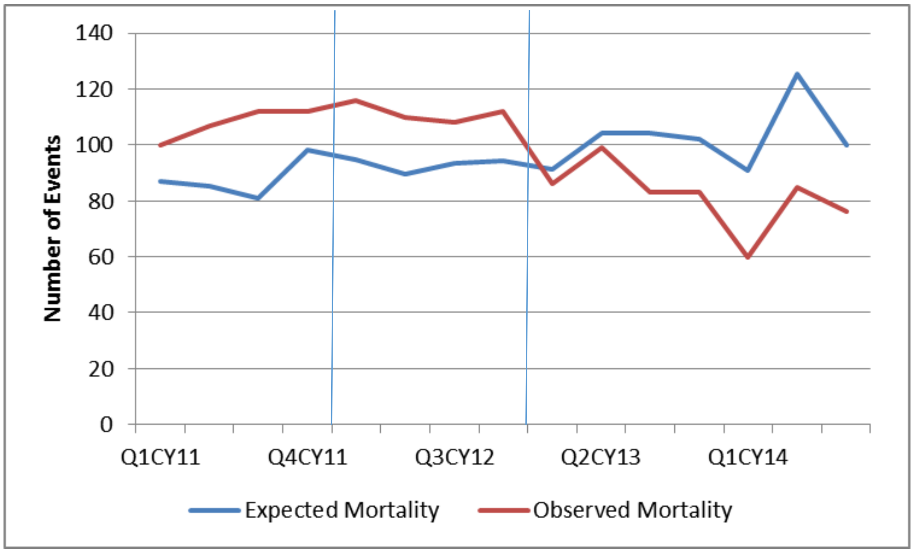


Figure 5. Change in Expected and Observed Mortality. Y-axis represents number of absolute mortalities and X-axis represents progression of quarters throughout the current and previous study. Q, quarter; CY, calendar year.



Discussion

Improving patient outcomes is multifactorial, but must include review of adverse events. Clarke et al advocated for a structured format in morbidity review in order to successfully determine root cause of adverse events[3]. Meanwhile Gupta et al advocated for committee based morbidity review over provider based review, as provider based review did not always correlate with committee based conclusions[4]. Our previous study combined both concepts and utilized a structured, surgeon led committee of morbidity and mortality review[6]. It demonstrated that an improvement in O:E ratio and patient outcome was observed using the new committee. However, long-term studies have not been completed. Therefore, the purpose of our current study was to determine long-term patient outcomes using the previously established structured, surgeon led committee on morbidity and mortality.

Analyzation of collected data demonstrated that long term review of patient morbidity and mortality yielded decreased O:E ratios, PSIs, and HACs (Table 1). Furthermore, data was representative of all the institution's 12 Department of Surgery divisions. This was important in order delineate differences between divisions and create the opportunity to target specific specialties for improvement. Higher proportions of adverse outcomes and PSIs were observed in services with higher acuity patient censuses, such as gastrointestinal surgery (69.4%), orthopedics (64.3%), otolaryngology (63.6%), surgical oncology (62.1%), and urology (77.4%). When a HAC was present among those services, average length of hospitalization tripled.

Once a mortality, PSI, or HAC was identified review of every event was additionally classified into the categories of preventable, possibly preventable, and not preventable during committee review. Elective operations were classified only as "possibly preventable" or "preventable", as the purely elective state automatically nulled a "not preventable" cause. In terms of mortality, significant association between the status of the operation (elective, urgent, emergency) and adverse outcomes (mortality and PSI) was demonstrated (tables 2-3). The majority of deaths were observed in non-elective settings (86.7%) and preventability for these deaths greatly varied. No significant patterns existed in this group. However, elective operations had a statistically significant larger proportion of possibly preventable mortalities. Once this trend was noted, identification of the root causes was established (see Figure 1). Interestingly, failure to escalate and failure to follow protocol were the largest contributors to possibly preventable deaths, representing nearly 50% of cases when combined. Identification was limited to PSI and mortality alone, as not enough data was obtained to detect a true statistical association with HACs.

Figure 5 demonstrates the overall decrease in absolute mortalities over the course of study. The data included our previous study and the consistently declining trend proves the sustainability of the new morbidity and mortality model in improving outcomes. While no statistically significant decrease was identified, a clinically significant decline in mortalities was identified with mortality decreasing from 100 to 76 over the course of study. Figure 3 additionally demonstrates the decline in O:E mortality ratio over the course of study, again including the previous study data. Figure 4 highlights the O:E mortality ratio for this study alone. The persistent O:E ratio less than 1.0 proves sustainability of the model over time. For these figures, the general trend of improved patient outcomes is observed when comparing historical data to data from our previous study to data from our current study.

The findings of older age and emergent operative status leading to higher death rates were compatible with previous studies[7]. Careful attention was paid to urgent and emergent operative outcomes as Ingraham et al had previously shown that hospitals with favorable outcomes after elective operations did not necessarily have such outcomes with emergent cases[8]. The average age of death was 61.5 and 64.4% of deaths were in the setting of emergency cases. Age and state of operation represented patient factors that could not be altered for future improvement of care. While those factors cannot be manipulated, a significant portion of patients with adverse events were not medically optimized prior to their operation. 5% of mortality and PSI were due to this. Utilization of preoperative risk stratification applications such as the NSQIP play a role in accurately defining operative risks by eliminating human judgment error. Routine use of this application could help reduce the number of patients undergoing an operation without adequate pre-operative optimization[9,10,11,12].

While NSQIP aids in pre-operative risk stratification, the introduction of quality structure with the new morbidity and mortality reviews showed a reduction in post-operative events. Throughout the duration of this study positive changes in patient outcomes were noted (figure 2, 3). A significant decrease in percentage of events among the entire surgery population was noted in each quarter, with mortality decreasing from 75% to 28% and PSI decreasing from 39% to 18%. Additionally, the O:E ratio declined throughout the period of the study and consistently remained below 1.0. These improvements were especially evident in the high-risk surgical specialties. This consistent long-term improvement in patient outcome supports the benefit of surgeon led, committee morbidity and mortality review processes. In addition to the implementation of quality structure, the application of the Early Warning Score (EWS) into the electronic medical chart proved to be effective in early identification and treatment of post-operative complications[13]. EWS is a system-wide application that trends vitals in the medical chart and produces a score based on abnormalities. High scores and large shifts prompt mandatory physician notification by nursing staff and also alert the rapid response medical team for quick assessment. This system was shown to decrease overall morbidity and mortality in the post-operative period by alerting physicians of changes in clinical status, therefore allowing for early transfer of patients to a higher level of care.

Limitations to this study included that a considerable number of patients were operated on while admitted under a non-surgical primary team, therefore were not admitted or discharged under a surgical service. As data was collected based on “admitted to” or “discharged from” a surgical service, these patients represent unpublished data. Other limitations included improper documentation potentially leading to falsely elevated O:E ratios and that a large proportion of preventable mortalities/PSIs etiologies were coded as “missing”.

Throughout the duration of this study a significant decrease in percentage of events among the entire surgery population was noted, specifically mortality, PSI, and O:E ratios among the high-risk surgical specialties. This consistent long-term improvement in patient outcome supports the benefit of surgeon led, committee morbidity and mortality review processes. With the identification of failure to escalate and failure to follow protocol as the leading causes of mortality and adverse events future research may focus on why these events occurred, which subsets of medical staff were involved, and how to correct those processes through education in order to improve patient care and prevent similar future events. Multidisciplinary involvement of all level of the healthcare team will be key in improving these health outcomes.

Conclusion

Our study demonstrates that a surgeon led, hospital wide process for reviewing morbidity and mortality in the long term positively impacts patient care by decreasing O:E ratios, mortality, and PSIs. These were especially evident in high risk surgical services. Areas of future research include identifying staff involved in root causes and discovering means to provide education to prevent future events.

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