

National Surgical Quality Improvement Program (NSQIP)

The Agency for Clinical Innovation (ACI) works with clinicians, consumers and managers to design and promote better healthcare for NSW. It does this through:

- *service redesign and evaluation* – applying redesign methodology to assist healthcare providers and consumers to review and improve the quality, effectiveness and efficiency of services
- *specialist advice on healthcare innovation* – advising on the development, evaluation and adoption of healthcare innovations from optimal use through to disinvestment
- *initiatives including guidelines and models of care* – developing a range of evidence-based healthcare improvement initiatives to benefit the NSW health system
- *implementation support* – working with ACI Networks, consumers and healthcare providers to assist delivery of healthcare innovations into practice across metropolitan and rural NSW
- *knowledge sharing* – partnering with healthcare providers to support collaboration, learning capability and knowledge sharing on healthcare innovation and improvement
- *continuous capability building* – working with healthcare providers to build capability in redesign, project management and change management through the Centre for Healthcare Redesign.

ACI Clinical Networks, Taskforces and Institutes provide a unique forum for people to collaborate across clinical specialties and regional and service boundaries to develop successful healthcare innovations.

A key priority for the ACI is identifying unwarranted variation in clinical practice. ACI teams work in partnership with healthcare providers to develop mechanisms aimed at reducing unwarranted variation and improving clinical practice and patient care.

aci.health.nsw.gov.au

AGENCY FOR CLINICAL INNOVATION

Level 4, 67 Albert Avenue
Chatswood NSW 2067

PO Box 699 Chatswood NSW 2057
T +61 2 9464 4666 | F +61 2 9464 4728
E aci-info@nsw.gov.au | **www.aci.health.nsw.gov.au**

SHPN (ACI) XXXXX, ISBN XXX-X-XXXXX-XXX-X.

Produced by: Name of Network, Institute or Taskforce if applicable.

Further copies of this publication can be obtained from
the Agency for Clinical Innovation website at **www.aci.health.nsw.gov.au**

Disclaimer: Content within this publication was accurate at the time of publication. This work is copyright. It may be reproduced in whole or part for study or training purposes subject to the inclusion of an acknowledgment of the source. It may not be reproduced for commercial usage or sale. Reproduction for purposes other than those indicated above, requires written permission from the Agency for Clinical Innovation.

Version: 1.0 **Trim:** ACI/D18/4002

Date Amended: 05/09/18

Review Date: 2023

© State of New South Wales (Agency for Clinical Innovation)

Contents

Contents	ii
Available Literature.....	1
1. National Surgical Quality Improvement Program: What Can Anesthesiologists Learn From Surgical Outcomes?	1
2. Improving the quality of surgical care: The American College of Surgeons National Surgical Quality Improvement Program.....	1
3. Surgeons overestimate postoperative complications and death when compared with the National Surgical Quality Improvement Project risk calculator.....	1
4. Transforming the National Surgical Quality Improvement Program to the Delivery of Precision Medicine to Improve the Value of Surgical Care: Summary of the John R. Clarke Keynote Address for the Surgical Outcomes Club 2016 Annual Meeting.	1
5. Evaluating the American College of Surgeons National Surgical Quality Improvement project risk calculator: results from the U.S. Extrahepatic Biliary Malignancy Consortium.	2
6. Validity of the American College of Surgeons' National Surgical Quality Improvement Program risk calculator in South Australian glossectomy patients.....	2
7. Improving Surgical Complications and Patient Safety at the Nation's Largest Military Hospital: An Analysis of National Surgical Quality Improvement Program Data.	3
8. Evaluation of the American College of Surgeons National Surgical Quality Improvement Program Surgical Risk Calculator in Gynecologic Oncology Patients Undergoing Minimally Invasive Surgery.	3
9. Improved Surgical Outcomes for ACS NSQIP Hospitals Over Time: Evaluation of Hospital Cohorts With up to 8 Years of Participation.	4
10. Evaluation of hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program.....	5
11. Development and Evaluation of the American College of Surgeons NSQIP Pediatric Surgical Risk Calculator.....	5
12. Evaluation and Enhancement of Calibration in the American College of Surgeons NSQIP Surgical Risk Calculator.....	6
13. Evaluation of the performance of the ACS NSQIP surgical risk calculator in gynecologic oncology patients undergoing laparotomy.....	7
14. Evaluation of the National Surgical Quality Improvement Program Universal Surgical Risk Calculator for a gynecologic oncology service.....	7
15. A Comprehensive Evaluation of Statistical Reliability in ACS NSQIP Profiling Models..	8
16. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons.	8
17. Optimizing ACS NSQIP modeling for evaluation of surgical quality and risk: patient risk adjustment, procedure mix adjustment, shrinkage adjustment, and surgical focus.....	9
18. Does surgical quality improve in the American College of Surgeons National Surgical Quality Improvement Program: an evaluation of all participating hospitals.	9

19. Can surgical performance benchmarking be generalized across multiple outcomes databases: a comparison of University HealthSystem Consortium and National Surgical Quality Improvement Program.	10
20. Impact of analysis of frozen-section margin on reoperation rates in women undergoing lumpectomy for breast cancer: evaluation of the National Surgical Quality Improvement Program data.	11
21. Measuring surgical quality: comparison of postoperative adverse events with the american college of surgeons NSQIP and the Thoracic Morbidity and Mortality classification system.	11
22. Quality improvement in gastrointestinal surgical oncology with American College of Surgeons National Surgical Quality Improvement Program.....	12
23. Macro vs micro level surgical quality improvement: a regional collaborative demonstrates the case for a national NSQIP initiative.....	12
24. Evaluation of initial participation in public reporting of American College of Surgeons NSQIP surgical outcomes on Medicare's Hospital Compare website.....	13
25. Validation of new readmission data in the American College of Surgeons National Surgical Quality Improvement Program.....	14
26. American College of Surgeons National Surgical Quality Improvement Program Pediatric: a beta phase report.	14
27. The power of the National Surgical Quality Improvement Program--achieving a zero pneumonia rate in general surgery patients.	15
28. The role of Surgical Champions in the American College of Surgeons National Surgical Quality Improvement Program--a national survey.	15
29. Improving American College of Surgeons National Surgical Quality Improvement Program risk adjustment: incorporation of a novel procedure risk score.....	16
30. Quality improvement in surgery: the American College of Surgeons National Surgical Quality Improvement Program approach. [Review]	16
31. Preliminary NSQIP results: a tool for quality improvement.	16
32. Toward robust information: data quality and inter-rater reliability in the American College of Surgeons National Surgical Quality Improvement Program.....	17
33. Missing data in the American College of Surgeons National Surgical Quality Improvement Program are not missing at random: implications and potential impact on quality assessments.....	18
34. Risk adjustment in the American College of Surgeons National Surgical Quality Improvement Program: a comparison of logistic versus hierarchical modeling.....	18
35. Implementation of the National Surgical Quality Improvement Program: critical steps to success for surgeons and hospitals.	19
36. Fifteen years of the National Surgical Quality Improvement Program in review.....	19
37. The National Surgical Quality Improvement Program: learning from the past and moving to the future.	19

38. Assessing surgical quality using administrative and clinical data sets: a direct comparison of the University HealthSystem Consortium Clinical Database and the National Surgical Quality Improvement Program data set.	20
39. Surrounded by quality metrics: what do surgeons think of ACS-NSQIP?	20
40. The NSQIP: a new frontier in surgery. [Review] [11 refs]	21

Available Literature

1. National Surgical Quality Improvement Program: What Can Anesthesiologists Learn From Surgical Outcomes?

Moller DH; Gan TJ.

Anesthesia & Analgesia. 127(1):15-17, 2018 Jul.

[Journal Article]

UI: 29912055

2. Improving the quality of surgical care: The American College of Surgeons National Surgical Quality Improvement Program.

Ellis RJ; Ko CY.

Revista de Calidad Asistencial. 32(6):301-302, 2017 Nov - Dec.

[Journal Article]

UI: 29137855

3. Surgeons overestimate postoperative complications and death when compared with the National Surgical Quality Improvement Project risk calculator.

Pei KY; Healy J; Davis KA.

Journal of Surgical Research. 225:95-100, 2018 May.

[Journal Article]

UI: 29605041

BACKGROUND: The assessment of postoperative morbidity and mortality is difficult particularly for complex patients. We hypothesize that surgeons overestimate the risk for complications and death after surgery in complex surgical patients.

MATERIALS AND METHODS: General surgery residents and attending surgeons estimated the likelihood of any morbidity, mortality, surgical site infection, pneumonia, and cardiac complications for seven complex scenarios. Responses were compared with the American College of Surgeons National Surgical Quality Improvement Project Surgical Risk Calculator.

RESULTS: From 101 residents and 48 attending surgeons, overall response rate was 61.7%. For all seven clinical scenarios, there was no difference between resident and attending predictions of morbidity or mortality, with significant variation in estimates among participants. Mean percentages of the estimates were 25.8%-30% over the National Surgical Quality Improvement Project estimates for morbidity and mortality.

CONCLUSIONS: General surgery residents and attending surgeons overestimated risks in complex surgical patients. These results demonstrate broad variance in and near universal overestimation of predicted surgical risk when compared with national, risk-adjusted model

4. Transforming the National Surgical Quality Improvement Program to the Delivery of Precision Medicine to Improve the Value of Surgical Care: Summary of the John R. Clarke Keynote Address for the Surgical Outcomes Club 2016 Annual Meeting.

Spertus JA; Ghaferi AA.

JAMA Surgery. 152(9):815-816, 2017 Sep 01.

[Journal Article]

UI: 28636703

5. Evaluating the American College of Surgeons National Surgical Quality Improvement project risk calculator: results from the U.S. Extrahepatic Biliary Malignancy Consortium.

Beal EW; Lyon E; Kearney J; Wei L; Ethun CG; Black SM; Dillhoff M; Salem A; Weber SM; Tran TB; Poultsides G; Shenoy R; Hatzaras I; Krasnick B; Fields RC; Buttner S; Scoggins CR; Martin RCG; Isom CA; Idrees K; Mogal HD; Shen P; Maithel SK; Pawlik TM; Schmidt CR.

HPB. 19(12):1104-1111, 2017 Dec.

[Evaluation Studies. Journal Article. Multicenter Study]

UI: 28890310

BACKGROUND: The objective of this study is to evaluate use of the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) online risk calculator for estimating common outcomes after operations for gallbladder cancer and extrahepatic cholangiocarcinoma.

METHODS: Subjects from the United States Extrahepatic Biliary Malignancy Consortium (USE-BMC) who underwent operation between January 1, 2000 and December 31, 2014 at 10 academic medical centers were included in this study. Calculator estimates of risk were compared to actual outcomes.

RESULTS: The majority of patients underwent partial or major hepatectomy, Whipple procedures or extrahepatic bile duct resection. For the entire cohort, c-statistics for surgical site infection (0.635), reoperation (0.680) and readmission (0.565) were less than 0.7. The c-statistic for death was 0.740. For all outcomes the actual proportion of patients experiencing an event was much higher than the median predicted risk of that event. Similarly, the group of patients who experienced an outcome did have higher median predicted risk than those who did not.

CONCLUSIONS: The ACS NSQIP risk calculator is easy to use but requires further modifications to more accurately estimate outcomes for some patient populations and operations for which validation studies show suboptimal performance.

6. Validity of the American College of Surgeons' National Surgical Quality Improvement Program risk calculator in South Australian glossectomy patients.

Kao SS; Frauenfelder C; Wong D; Edwards S; Krishnan S; Ooi EH.

Journal of Laryngology & Otology. 132(2):173-179, 2018 Feb.

[Comparative Study. Journal Article. Multicenter Study. Validation Studies]

UI: 28720161

BACKGROUND: Appropriate selection of tongue cancer patients considering surgery is critical in ensuring optimal outcomes. The American College of Surgeons' National Surgical Quality Improvement Program ('ACS-NSQIP') risk calculator was developed to assess patients' 30-day post-operative risk, providing surgeons with information to guide decision making.

METHOD: A retrospective review of 30-day actual mortality and morbidity of tongue cancer patients was undertaken to investigate the validity of this tool for South Australian patients treated from 2005 to 2015.

RESULTS: One hundred and twenty patients had undergone glossectomy. Predicted length of stay using the risk calculator was significantly different from actual length of stay. Predicted mortality and other complications were found to be similar to actual outcomes.

CONCLUSION: The American College of Surgeons' National Surgical Quality Improvement Program risk calculator was found to be effective in predicting post-operative complication rates in South Australian tongue cancer patients. However, significant discrepancies in predicted and actual length of stay may limit its use in this population.

7. Improving Surgical Complications and Patient Safety at the Nation's Largest Military Hospital: An Analysis of National Surgical Quality Improvement Program Data.

Maturo S; Hughes C; Kallungal G; Silvey S; Johnson AJ; Soderdahl D; Renz E; Brennan J.
Military Medicine. 182(3):e1752-e1755, 2017 Mar.

[Journal Article]

UI: 28290954

INTRODUCTION: The U.S. Military Health System cares for over 9 million patients and encompasses 63 hospitals and 413 clinics worldwide. Military medicine balances the simultaneous tasks of caring for those patients wounded in military engagements, treating large numbers of families of service men and women, and training the next generation of health care providers and ancillary staff. Similar to civilian health care delivery in the United States, military medicine has also seen increased scrutiny in the areas of cost and quality. In 2014, the U.S. military medical health care system was criticized for higher than average surgical complication rates and concerns regarding patient safety, quality of care, lack of transparency, and compartmentalized leadership. The San Antonio Military Medical Center was specifically cited as having "a perennial problem with surgical infection control...the infection rate of surgical wounds was 77% higher than expected given the mix of cases, according to a Pentagon-ordered comparison with civilian hospitals." To determine the scope of complication rates, data from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) were analyzed. The goal of this article is to describe the NSQIP surgical outcome data for the U.S. Military's largest medical center from 2009 to 2014 and compare national averages in the areas of mortality, morbidity, cardiac occurrences, pneumonia, unplanned intubation, ventilator use greater than 48 hours, infections, readmissions, and return to operating room.

MATERIALS AND METHODS: Retrospective data analysis of NSQIP data from 2009 to 2014 at the San Antonio Military Medical Center, a level I trauma center for military members and eligible dependents along with civilian trauma patients. Observed event rates were compared with expected event rates for each year with the 2-tail Fisher's exact test to determine if rates were significantly different from each other. Cochran-Armitage Trend Test was performed to compare trends in time for the observed event rates. This study was exempt from institutional review board Approval.

RESULTS: Complication rates remained stable or decreased over the 5 years studied. Significant improvement in morbidity and surgical site infections were observed during the observation period. All other variables except urinary tract infections were within expected range or decreased during this time. Urinary tract infection rates, although decreasing, remain above the expected value.

CONCLUSIONS AND RELEVANCE: NSQIP data at the Department of Defense's largest hospital reveals complication rates similar to civilian hospitals. The majority of areas studied revealed improving or stable complication rates. The ACS NSQIP is a nationally validated, risk-adjusted, outcomes program that is widely used by many leading hospital institutions. Similar to most quality data reporting articles, a weakness of our study may have been collection of all complications. Yet, we are confident that the majority of complications were captured as we have dedicated personnel monitoring the adverse events measured by ACS NSQIP. Future areas of study should focus on continued analysis of surgical quality improvement within the entire military system.

8. Evaluation of the American College of Surgeons National Surgical Quality Improvement Program Surgical Risk Calculator in Gynecologic Oncology Patients Undergoing Minimally Invasive Surgery.

Teoh D; Halloway RN; Heim J; Vogel RI; Rivard C.

Journal of Minimally Invasive Gynecology. 24(1):48-54, 2017 01 01.

[Journal Article. Research Support, N.I.H., Extramural. Research Support, Non-U.S. Gov't]

UI: 27789387

STUDY OBJECTIVE: To evaluate the ability of the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) surgical risk calculator to predict discharge to postacute care and perioperative complications in gynecologic oncology patients undergoing minimally invasive surgery (MIS).

DESIGN: A retrospective chart review (Canadian Task Force classification II-1).

SETTING: A university hospital.

PATIENTS: All patients undergoing MIS on the gynecologic oncology service from January 1, 2009, to December 30, 2013.

INTERVENTIONS: Surgical procedures were reviewed, and appropriate Common Procedural Terminology codes were assigned. Twenty-one preoperative risk factors were abstracted from the chart and entered into the ACS NSQIP surgical risk calculator. The predicted risk of discharge to postacute care and 8 additional postoperative complications were calculated and recorded. Actual postoperative complications were abstracted from the medical record. The association between the calculated risk and the actual outcome was determined using logistic regression. The ability of the calculator to accurately predict a particular event was assessed using the c-statistic and Brier score.

MEASUREMENTS AND MAIN RESULTS: Of the 876 patients reviewed, a majority underwent hysterectomy (71.6%), with almost half of those patients undergoing additional cancer staging procedures (34.8%). Although the calculator was a poor predictor of postoperative complications, it was a strong predictor for discharge to postacute care (c-statistic = 0.91, Brier score = 0.02) with an odds ratio of 2.31 (95% confidence interval, 1.65-3.25; $p < .0001$).

CONCLUSION: The ACS NSQIP surgical risk calculator does not accurately predict postoperative complications or length of stay in gynecologic oncology patients undergoing MIS. Although it was a strong predictor of need for discharge to postacute care, it vastly overestimated the number of patients requiring this service. Therefore, the calculator's risk score for discharge to postacute care may be considered during preoperative counseling but should not be a predictor of whether or not the patient should proceed with surgery.

9. Improved Surgical Outcomes for ACS NSQIP Hospitals Over Time: Evaluation of Hospital Cohorts With up to 8 Years of Participation.

Cohen ME; Liu Y; Ko CY; Hall BL.

Annals of Surgery. 263(2):267-73, 2016 Feb.

[Evaluation Studies. Journal Article]

UI: 25723845

BACKGROUND: The American College of Surgeons, National Surgical Quality Improvement Program (ACS NSQIP) surgical quality feedback models are recalibrated every 6 months, and each hospital is given risk-adjusted, hierarchical model, odds ratios that permit comparison to an estimated average NSQIP hospital at a particular point in time. This approach is appropriate for "relative" benchmarking, and for targeting quality improvement efforts, but does not permit evaluation of hospital or program-wide changes in quality over time. We report on long-term improvement in surgical outcomes associated with participation in ACS NSQIP.

STUDY DESIGN: ACS NSQIP data (2006-2013) were used to create prediction models for mortality, morbidity (any of several distinct adverse outcomes), and surgical site infection (SSI). For each model, for each hospital, and for year of first participation (hospital cohort), hierarchical model observed/expected (O/E) ratios were computed. The primary performance metric was the within-hospital trend in logged O/E ratios over time (slope) for mortality, morbidity, and SSI.

RESULTS: Hospital-averaged log O/E ratio slopes were generally negative, indicating improving performance over time. For all hospitals, 62%, 70%, and 65% of hospitals had negative slopes for mortality, morbidity, and any SSI, respectively. For hospitals currently in the program for at least 3 years, 69%, 79%, and 71% showed improvement in mortality, morbidity, and SSI, respectively. For these hospitals, we estimate 0.8%, 3.1%, and 2.6% annual reductions (with respect to prior year's rates) for mortality, morbidity, and SSI, respectively.

CONCLUSIONS: Participation in ACS NSQIP is associated with reductions in adverse events after surgery. The magnitude of quality improvement increases with time in the program.

10. Evaluation of hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program.

Sheils CR; Dahlke AR; Kreutzer L; Bilimoria KY; Yang AD.

Surgery. 160(5):1182-1188, 2016 11.

[Comparative Study. Evaluation Studies. Journal Article]

UI: 27302100

BACKGROUND: The American College of Surgeons National Surgical Quality Improvement Program is well recognized in surgical quality measurement and is used widely in research. Recent calls to make it a platform for national public reporting and pay-for-performance initiatives highlight the importance of understanding which types of hospitals elect to participate in the program. Our objective was to compare characteristics of hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program to characteristics of nonparticipating US hospitals.

METHODS: The 2013 American Hospital Association and Centers for Medicare & Medicaid Services Healthcare Cost Report Information System datasets were used to compare characteristics and operating margins of hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program to those of nonparticipating hospitals.

RESULTS: Of 3,872 general medical and surgical hospitals performing inpatient surgery in the United States, 475 (12.3%) participated in the American College of Surgeons National Surgical Quality Improvement Program. Participating hospitals performed 29.0% of all operations in the United States. Compared with nonparticipating hospitals, American College of Surgeons National Surgical Quality Improvement Program hospitals had a higher mean annual inpatient surgical case volume (6,426 vs 1,874; $P < .001$) and a larger mean number of hospital beds (420 vs 167; $P < .001$); participating hospitals were more often teaching hospitals (35.2% vs 4.1%; $P < .001$), had more quality-related accreditations ($P < .001$), and had higher mean operating margins ($P < .05$). States with the highest proportions of hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program had established surgical quality improvement collaboratives.

CONCLUSION: The American College of Surgeons National Surgical Quality Improvement Program hospitals are large teaching hospitals with more quality-related accreditations and financial resources. These findings should be considered when reviewing research studies using the American College of Surgeons National Surgical Quality Improvement Program data, and the findings reinforce that efforts are needed to facilitate participation in surgical quality improvement by all hospital types.

11. Development and Evaluation of the American College of Surgeons NSQIP Pediatric Surgical Risk Calculator.

Kraemer K; Cohen ME; Liu Y; Barnhart DC; Rangel SJ; Saito JM; Bilimoria KY; Ko CY; Hall BL.

Journal of the American College of Surgeons. 223(5):685-693, 2016 Nov.

[Evaluation Studies. Journal Article]

UI: 27666656

BACKGROUND: There is an increased desire among patients and families to be involved in the surgical decision-making process. A surgeon's ability to provide patients and families with patient-specific estimates of postoperative complications is critical for shared decision making and informed consent. Surgeons can also use patient-specific risk estimates to decide whether or not to operate and what options to offer patients. Our objective was to develop and evaluate a publicly available risk estimation tool that would cover many common pediatric surgical procedures across all specialties.

STUDY DESIGN: American College of Surgeons NSQIP Pediatric standardized data from 67 hospitals were used to develop a risk estimation tool. Surgeons enter 18 preoperative variables (demographics, comorbidities, procedure) that are used in a logistic regression model to predict 9 postoperative outcomes. A surgeon adjustment score is also incorporated to adjust for any additional risk not accounted for in the 18 risk factors.

RESULTS: A pediatric surgical risk calculator was developed based on 181,353 cases covering 382 CPT codes across all specialties. It had excellent discrimination for mortality (c-statistic = 0.98), morbidity (c-statistic = 0.81), and 7 additional complications (c-statistic > 0.77). The Hosmer-Lemeshow statistic and graphic representations also showed excellent calibration.

CONCLUSIONS: The ACS NSQIP Pediatric Surgical Risk Calculator was developed using standardized and audited multi-institutional data from the ACS NSQIP Pediatric, and it provides empirically derived, patient-specific postoperative risks. It can be used as a tool in the shared decision-making process by providing clinicians, families, and patients with useful information for many of the most common operations performed on pediatric patients in the US.

12. Evaluation and Enhancement of Calibration in the American College of Surgeons NSQIP Surgical Risk Calculator.

Liu Y; Cohen ME; Hall BL; Ko CY; Bilimoria KY.

Journal of the American College of Surgeons. 223(2):231-9, 2016 Aug.

[Evaluation Studies. Journal Article]

UI: 27212006

BACKGROUND: The American College of Surgeon (ACS) NSQIP Surgical Risk Calculator has been widely adopted as a decision aid and informed consent tool by surgeons and patients. Previous evaluations showed excellent discrimination and combined discrimination and calibration, but model calibration alone, and potential benefits of recalibration, were not explored. Because lack of calibration can lead to systematic errors in assessing surgical risk, our objective was to assess calibration and determine whether spline-based adjustments could improve it.

STUDY DESIGN: We evaluated Surgical Risk Calculator model calibration, as well as discrimination, for each of 11 outcomes modeled from nearly 3 million patients (2010 to 2014). Using independent random subsets of data, we evaluated model performance for the Development (60% of records), Validation (20%), and Test (20%) datasets, where prediction equations from the Development dataset were recalibrated using restricted cubic splines estimated from the Validation dataset. We also evaluated performance on data subsets composed of higher-risk operations.

RESULTS: The nonrecalibrated Surgical Risk Calculator performed well, but there was a slight tendency for predicted risk to be overestimated for lowest- and highest-risk patients and underestimated for moderate-risk patients. After recalibration, this distortion was eliminated, and p values for miscalibration were most often nonsignificant. Calibration was also excellent for subsets of higher-risk operations, though observed calibration was reduced due to instability associated with smaller sample sizes.

CONCLUSIONS: Performance of NSQIP Surgical Risk Calculator models was shown to be excellent and improved with recalibration. Surgeons and patients can rely on the calculator to provide accurate estimates of surgical risk.

13. Evaluation of the performance of the ACS NSQIP surgical risk calculator in gynecologic oncology patients undergoing laparotomy.

Rivard C; Nahum R; Slagle E; Duininck M; Isaksson Vogel R; Teoh D.

Gynecologic Oncology. 141(2):281-286, 2016 05.

[Journal Article. Research Support, Non-U.S. Gov't. Research Support, N.I.H., Extramural]

UI: 26899020

OBJECTIVE: The objective of this study was to evaluate the ability of the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) surgical risk calculator to predict complications in gynecologic oncology patients undergoing laparotomy.

METHODS: A chart review of patients who underwent laparotomy on the gynecologic oncology service at a single academic hospital from January 2009 to December 2013 was performed.

Preoperative variables were abstracted and NSQIP surgical risk scores were calculated. The risk of any complication, serious complication, death, urinary tract infection, venous thromboembolism, cardiac event, renal complication, pneumonia and surgical site infection were correlated with actual patient outcomes using logistic regression. The c-statistic and Brier score were used to calculate the prediction capability of the risk calculator.

RESULTS: Of the 1094 patients reviewed, the majority were <65years old (70.9%), independent (95.2%), ASA class 1-2 (67.3%), and overweight or obese (76.1%). Higher calculated risk scores were associated with an increased risk of the actual complication occurring for all events ($p < 0.05$). The calculator performed best for predicting death (c-statistic=0.851, Brier=0.008), renal failure (c-statistic=0.752, Brier=0.015) and cardiac complications (c-statistic=0.708, Brier=0.011). The calculator did not accurately predict most complications.

CONCLUSIONS: The NSQIP surgical risk calculator adequately predicts specific serious complications, such as postoperative death and cardiac complications. However, the overall performance of the calculator was worse for gynecologic oncology patients than reported in general surgery patients. A tailored prediction model may be needed for this patient population.

14. Evaluation of the National Surgical Quality Improvement Program Universal Surgical Risk Calculator for a gynecologic oncology service.

Szender JB; Frederick PJ; Eng KH; Akers SN; Lele SB; Odunsi K.

International Journal of Gynecological Cancer. 25(3):512-20, 2015 Mar.

[Journal Article. Research Support, N.I.H., Extramural]

UI: 25628106

OBJECTIVES: The National Surgical Quality Improvement Program is aimed at preventing perioperative complications. An online calculator was recently published, but the primary studies used limited gynecologic surgery data. The purpose of this study was to evaluate the performance of the National Surgical Quality Improvement Program Universal Surgical Risk Calculator (URC) on the patients of a gynecologic oncology service.

STUDY DESIGN: We reviewed 628 consecutive surgeries performed by our gynecologic oncology service between July 2012 and June 2013. Demographic data including diagnosis and cancer stage, if applicable, were collected. Charts were reviewed to determine complication rates. Specific complications were as follows: death, pneumonia, cardiac complications, surgical site infection (SSI) or urinary tract infection, renal failure, or venous thromboembolic event. Data were compared with modeled outcomes using Brier scores and receiver operating characteristic curves.

Significance was declared based on $P < 0.05$.

RESULTS: The model accurately predicated death and venous thromboembolic event, with Brier scores of 0.004 and 0.003, respectively. Predicted risk was 50% greater than experienced for urinary tract infection; the experienced SSI and pneumonia rates were 43% and 36% greater than predicted. For any complication, the Brier score 0.023 indicates poor performance of the model.

CONCLUSIONS: In this study of gynecologic surgeries, we could not verify the predictive value of the URC for cardiac complications, SSI, and pneumonia. One disadvantage of applying a URC to multiple subspecialties is that with some categories, complications are not accurately estimated. Our data demonstrate that some predicted risks reported by the calculator need to be interpreted with reservation.

15. A Comprehensive Evaluation of Statistical Reliability in ACS NSQIP Profiling Models.

Huffman KM; Cohen ME; Ko CY; Hall BL.

Annals of Surgery. 261(6):1108-13, 2015 Jun.

[Journal Article]

UI: 25211276

OBJECTIVE: To assess statistical reliability of hospital profiling models in ACS NSQIP (American College of Surgeons' National Surgical Quality Improvement Program).

BACKGROUND: The ACS NSQIP January 2013 Semiannual Report provided risk-adjusted hospital quality assessments for 137 models.

METHODS: Median reliability and percentage of hospitals achieving acceptable reliability were computed for each model. Average median reliability was computed across models with common outcomes.

RESULTS: Median reliability varied across the 137 models, from a high of 0.91 for "All Cases Morbidity" to a low of 0.005 for "Procedure-Targeted Total Hip Arthroplasty Surgical Site Infection." Generally, reliability was greatest for models with larger sample sizes and higher outcome event rates. Among "Essentials" models, 72% attained a median reliability of 0.40 or more, and 24% of 0.70 or more. Among "Procedure-Targeted" models, 29% attained a median reliability of 0.40 or more, and 3% of 0.70 or more. Percentage of hospitals achieving an acceptable reliability of 0.40 ranged from 98% for "All Cases Morbidity" to 0% for "Procedure-Targeted Pancreatectomy Mortality." For Essentials models, average median reliability for each outcome, except mortality, was more than 0.40. However, for Procedure-Targeted models the average median was less than 0.40.

CONCLUSIONS: For a large proportion of ACS NSQIP Essentials models, statistical reliability is adequate for assessing surgical quality and differentiating hospital performance. The Procedure-Targeted program is evolving in terms of statistical reliability, with promising results to date. These results also argue for broader discussions of statistical reliability in performance assessments for the profession.

16. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons.

Bilimoria KY; Liu Y; Paruch JL; Zhou L; Kmiecik TE; Ko CY; Cohen ME.

Journal of the American College of Surgeons. 217(5):833-42.e1-3, 2013 Nov.

[Journal Article. Research Support, U.S. Gov't, P.H.S.]

UI: 24055383

BACKGROUND: Accurately estimating surgical risks is critical for shared decision making and informed consent. The Centers for Medicare and Medicaid Services may soon put forth a measure requiring surgeons to provide patients with patient-specific, empirically derived estimates of postoperative complications. Our objectives were to develop a universal surgical risk estimation

tool, to compare performance of the universal vs previous procedure-specific surgical risk calculators, and to allow surgeons to empirically adjust the estimates of risk.

STUDY DESIGN: Using standardized clinical data from 393 ACS NSQIP hospitals, a web-based tool was developed to allow surgeons to easily enter 21 preoperative factors (demographics, comorbidities, procedure). Regression models were developed to predict 8 outcomes based on the preoperative risk factors. The universal model was compared with procedure-specific models. To incorporate surgeon input, a subjective surgeon adjustment score, allowing risk estimates to vary within the estimate's confidence interval, was introduced and tested with 80 surgeons using 10 case scenarios.

RESULTS: Based on 1,414,006 patients encompassing 1,557 unique CPT codes, a universal surgical risk calculator model was developed that had excellent performance for mortality (c-statistic = 0.944; Brier score = 0.011 [where scores approaching 0 are better]), morbidity (c-statistic = 0.816, Brier score = 0.069), and 6 additional complications (c-statistics > 0.8). Predictions were similarly robust for the universal calculator vs procedure-specific calculators (eg, colorectal). Surgeons demonstrated considerable agreement on the case scenario scoring (80% to 100% agreement), suggesting reliable score assignment between surgeons.

CONCLUSIONS: The ACS NSQIP surgical risk calculator is a decision-support tool based on reliable multi-institutional clinical data, which can be used to estimate the risks of most operations. The ACS NSQIP surgical risk calculator will allow clinicians and patients to make decisions using empirically derived, patient-specific postoperative risks.

17. Optimizing ACS NSQIP modeling for evaluation of surgical quality and risk: patient risk adjustment, procedure mix adjustment, shrinkage adjustment, and surgical focus.

Cohen ME; Ko CY; Bilimoria KY; Zhou L; Huffman K; Wang X; Liu Y; Kraemer K; Meng X; Merkow R; Chow W; Matel B; Richards K; Hart AJ; Dimick JB; Hall BL.

Journal of the American College of Surgeons. 217(2):336-46.e1, 2013 Aug.

[Journal Article]

UI: 23628227

The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) collects detailed clinical data from participating hospitals using standardized data definitions, analyzes these data, and provides participating hospitals with reports that permit risk-adjusted comparisons with a surgical quality standard. Since its inception, the ACS NSQIP has worked to refine surgical outcomes measurements and enhance statistical methods to improve the reliability and validity of this hospital profiling. From an original focus on controlling for between-hospital differences in patient risk factors with logistic regression, ACS NSQIP has added a variable to better adjust for the complexity and risk profile of surgical procedures (procedure mix adjustment) and stabilized estimates derived from small samples by using a hierarchical model with shrinkage adjustment. New models have been developed focusing on specific surgical procedures (eg, "Procedure Targeted" models), which provide opportunities to incorporate indication and other procedure-specific variables and outcomes to improve risk adjustment. In addition, comparative benchmark reports given to participating hospitals have been expanded considerably to allow more detailed evaluations of performance. Finally, procedures have been developed to estimate surgical risk for individual patients. This article describes the development of, and justification for, these new statistical methods and reporting strategies in ACS NSQIP.

18. Does surgical quality improve in the American College of Surgeons National Surgical Quality Improvement Program: an evaluation of all participating hospitals.

Hall BL; Hamilton BH; Richards K; Bilimoria KY; Cohen ME; Ko CY.

Annals of Surgery. 250(3):363-76, 2009 Sep.

[Journal Article. Research Support, Non-U.S. Gov't]

UI: 19644350

BACKGROUND/OBJECTIVE: The National Surgical Quality Improvement Program (NSQIP) has demonstrated quality improvement in the VA and pilot study of 14 academic institutions. The objective was to show that American College of Surgeons (ACS)-NSQIP helps all enrolled hospitals.

METHODS: ACS-NSQIP data was used to evaluate improvement in hospitals longitudinally over 3 years (2005-2007). Improvement was defined as reduction in risk-adjusted "Observed/Expected" (O/E) ratios between periods with risk adjustment held constant. Multivariable logistic regression-based adjustment was performed and included indicators for procedure groups. Additionally, morbidity counts were modeled using a negative binomial model, to estimate the number of avoided complications.

RESULTS: Multiple perspectives reflected improvement over time. In the analysis of 118 hospitals (2006-2007), 66% of hospitals improved risk-adjusted mortality (mean O/E improvement: 0.174; $P < 0.05$) and 82% improved risk adjusted complication rates (mean improvement: 0.114; $P < 0.05$). Correlations between starting O/E and improvement (0.834 for mortality, 0.652 for morbidity), as well as relative risk, revealed that initially worse-performing hospitals had more likelihood of improvement. Nonetheless, well-performing hospitals also improved. Modeling morbidity counts, 183 hospitals (2007), avoided ~9598 potential complications: ~52/hospital. Due to sampling this may represent only 1 of 5 to 1 of 10 of the true total. Improvement reflected aggregate performance across all types of hospitals (academic/community, urban/rural). Changes in patient risk over time had important contributions to the effect.

CONCLUSIONS: ACS-NSQIP indicates that surgical outcomes improve across all participating hospitals in the private sector. Improvement is reflected for both poor- and well-performing facilities. NSQIP hospitals appear to be avoiding substantial numbers of complications- improving care, and reducing costs. Changes in risk over time merit further study.

19. Can surgical performance benchmarking be generalized across multiple outcomes databases: a comparison of University HealthSystem Consortium and National Surgical Quality Improvement Program.

Simorov A; Bills N; Shostrom V; Boilesen E; Oleynikov D.

American Journal of Surgery. 208(6):942-8; discussion 947-8, 2014 Dec.

[Comparative Study. Journal Article. Research Support, Non-U.S. Gov't]

UI: 25440482

BACKGROUND: Surgeon's performance is tracked using patient outcomes databases. We compared data on patients undergoing laparoscopic cholecystectomy from 2 large databases with significant institutional overlap to see if either patient characteristics or outcomes were similar enough to accurately compare performance.

METHODS: Data from 2009 to 2011 were collected from University HealthSystem Consortium (UHC) and National Surgical Quality Improvement Program (NSQIP). UHC and NSQIP collect data from over 200 and 400 medical centers, respectively, with an overlap of 70. Patient demographics, pre-existing medical conditions, operative details, and outcomes were compared.

RESULTS: Fifty-six thousand one hundred ninety-seven UHC patients and 56,197 NSQIP patients met criteria. Groups were matched by age, sex, and pre-existing comorbidities. Outcomes for NSQIP and UHC differed, including mortality (.20% NSQIP vs .12% UHC; $P < .0001$), morbidity (2.0% vs 1.5%; $P < .0001$), wound infection (.07% vs .33%; $P < .0001$), pneumonia (.38% vs .75%; $P < .0001$), urinary tract infections (.62% vs .01%; $P < .0001$), and length of hospital stay (1.8 +/- 7.5 vs 3.8 +/- 3.7 days; $P = .0004$), respectively.

CONCLUSIONS: Surgical outcomes are significantly different between databases and resulting performance data may be significantly biased. A single unified national database may be required to correct this problem.

20. Impact of analysis of frozen-section margin on reoperation rates in women undergoing lumpectomy for breast cancer: evaluation of the National Surgical Quality Improvement Program data.

Boughey JC. Hieken TJ. Jakub JW. Degnim AC. Grant CS. Farley DR. Thomsen KM. Osborn JB. Keeney GL. Habermann EB.

Surgery. 156(1):190-7, 2014 Jul.

BACKGROUND: Reoperation for positive margins after lumpectomy for breast cancer is common. Intraoperative analysis of frozen-section (FS) margins permits immediate re-excision, avoiding reoperation. The aim of this study was to compare reoperation rates between an institution using routine FS analysis of all margins and the National Surgical Quality Improvement Program (NSQIP) data.

METHODS: We designed a retrospective cohort analysis comparing the NSQIP data from a FS single institution with the national NSQIP data from 2006 to 2010. Women undergoing lumpectomy for cancer were identified (N = 24,217), and reoperation rates were compared by the use of chi(2) analyses and multivariable logistic regression. During this time period, NSQIP did not differentiate between reoperations for complications or oncologic reasons. Reoperation rates for mastectomy patients (N = 21,734) and lumpectomy patients without cancer (N = 2,777) over the same time period were analyzed as controls, because reoperations after these procedures likely would be for reasons other than positive margins.

RESULTS: The 30-day reoperation rate after lumpectomy for cancer was greater nationally than at the FS institution (13.2% vs 3.6%, $P < .001$). Multivariable analysis showed that patients in the national NSQIP data set were over four times as likely to undergo reoperation as those at the FS institution's (odds ratio 4.19). The reoperation rates were similar between the two, both for patients undergoing mastectomy (4.7% vs 4.5%, $P = .84$) and those undergoing lumpectomy for benign diagnosis (2.9% vs 5.9%, $P = .39$).

CONCLUSION: Intraoperative FS margin analysis decreases the number of reoperations for patients undergoing breast conservation for breast cancer. This technique has important implications for patient satisfaction and cost of care. Copyright 2014 Mosby, Inc. All rights reserved.

21. Measuring surgical quality: comparison of postoperative adverse events with the american college of surgeons NSQIP and the Thoracic Morbidity and Mortality classification system.

Ivanovic J. Seely AJ. Anstee C. Villeneuve PJ. Gilbert S. Maziak DE. Shamji FM. Forster AJ. Sundaresan RS.

Journal of the American College of Surgeons. 218(5):1024-31, 2014 May.

BACKGROUND: Monitoring surgical outcomes is critical to quality improvement; however, different data-collection methodologies can provide divergent evaluations of surgical outcomes. We compared postoperative adverse event reporting on the same patients using 2 classification systems: the retrospectively recorded American College of Surgeons (ACS) NSQIP and the prospectively collected Thoracic Morbidity and Mortality (TM&M) system.

STUDY DESIGN: Using the TM&M system, complications and deaths were documented daily by fellows and reviewed weekly by staff for all thoracic surgical cases conducted at our institution (April 1, 2010 to December 31, 2011). The ACS NSQIP recording was performed 30 to 120 days after index surgery by trained surgical clinical reviewers on a systemic sampling of major cases during the same time period. Univariate analyses of the data were performed.

RESULTS: During the study period, 1,788 thoracic procedures were performed (1,091 were designated "major," as per ACS NSQIP inclusion criteria). The ACS NSQIP evaluated 182 of these procedures, representing 21.1% and 16.7% of patients and procedures, respectively. Mortality rates were 1.4% in TM&M vs 2.2% in ACS NSQIP ($p = 0.42$). Total patients and procedures with complications reported were 24.4% and 31.1% by TM&M vs 20.2% and 39.0% by ACS NSQIP ($p = 0.23$ and 0.03), respectively. Rates of reported cardiac complications were higher in TM&M vs ACS NSQIP (5.8% vs 1.1%; $p = 0.01$), and wound complications were lower (2.5% vs 6.0%; $p = 0.01$). **CONCLUSIONS:** Although overall rates were similar, significant differences in collection, definitions, and classification of postoperative adverse events were observed when comparing TM&M and ACS NSQIP. Although both systems offer complementary value, harmonization of definitions and severity classification would enhance quality-improvement programs. Copyright 2014 American College of Surgeons

22. Quality improvement in gastrointestinal surgical oncology with American College of Surgeons National Surgical Quality Improvement Program.

Lucas DJ. Pawlik TM.

Surgery. 155(4):593-601, 2014 Apr.

OBJECTIVE: To assess the impact of American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) participation on outcomes in gastrointestinal surgical oncology.

STUDY DESIGN: A total of 6,076 resections for esophageal, gastric, pancreatic, hepatobiliary, and colorectal cancers at 316 hospitals from the 2006 to 2011 ACS NSQIP were examined. Thirty-day complication rates were analyzed longitudinally over time with the use of multiple regression; we adjusted for operation type and preoperative risk factors.

RESULTS: The procedure mix was 3% esophagectomy, 5% gastrectomy, 16% pancreatectomy, 4% hepatectomy, 63% colectomy, and 9% proctectomy. Median age was 66 years, and 52% were male, 41% were American Society of Anesthesiologists class 2, and 52% were American Society of Anesthesiologists 3. Depending on anatomic surgical site, 21-45% of patients experienced a postoperative complication and 1.1-4.4% died. The incidence of patients with any complication decreased from 28 to 24% over the period (risk-adjusted odds ratio 0.95 per year, 95% confidence interval 0.94-0.96). In contrast, there was no substantial change in risk-adjusted mortality over the period (odds ratio 1.03, 95% confidence interval 0.99-1.07).

CONCLUSION: There was a decrease in complications over time for ACS NSQIP participants in gastrointestinal surgical oncology, but mortality did not decrease. Copyright 2014 Mosby, Inc. All rights reserved.

23. Macro vs micro level surgical quality improvement: a regional collaborative demonstrates the case for a national NSQIP initiative.

Tepas JJ 3rd. Kerwin AJ. deVilla J. Nussbaum MS.

Journal of the American College of Surgeons. 218(4):599-604, 2014 Apr.

BACKGROUND: The Florida Surgical Care Initiative (FSCI) is a quality improvement collaborative of the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) and the Florida Hospital Association. In the wake of a dramatic decrease in complications and cost documented over 15 months, we analyzed the semiannual measures reports (SAR) to determine whether this improvement was driven by specific institutions or was a global accomplishment by all participants.

METHODS: Reports from NSQIP were analyzed to determine rank change of participants. Odds ratio (OR) of observed-to-expected incidence of the 4 FSCI outcomes (catheter-associated urinary tract infection [CAUTI], surgical site infection [SSI], colorectal, and surgery in patients older than 65

years) were used to assess individual and group performance. Data from SAR 2 (October 2011 to April 2012) were compared with data from SAR 3 (May to July 2012). Poorly performing hospitals were tracked to determine evidence of improvement. Individual facility performance was evaluated by determining proportion of hospitals showing improved rank across all measures.

RESULTS: Fifty-four hospitals were evaluated. SAR 2 reported 28,112 general and vascular surgical cases; SAR 3 added 10,784 more. The proportion of institutions with OR < 1 for each measure did not change significantly. Only urinary tract infection and colorectal measures demonstrated increased number of hospitals with OR < 1. Each institution that was a significant negative outlier in SAR 2 demonstrated improvement. Three of 54 hospitals demonstrated improvement across all 4 measures. Of 15 hospitals with improved performance across 3 measures, all included elderly surgery.

CONCLUSIONS: The increase in quality achieved across this population of surgical patients was the result of a quality assessment process driven by NSQIP rather than disproportionate improvement of some raising the bar for all. The NSQIP process, applied collaboratively across a population by committed institutions, produces dramatic results. Copyright 2014 American College of Surgeons.

24. Evaluation of initial participation in public reporting of American College of Surgeons NSQIP surgical outcomes on Medicare's Hospital Compare website.

Dahlke AR. Chung JW. Holl JL. Ko CY. Rajaram R. Modla L. Makary MA. Bilimoria KY. *Journal of the American College of Surgeons*. 218(3):374-80, 380.e1-5, 2014 Mar.

BACKGROUND: In October 2012, The Centers for Medicare and Medicaid Services (CMS) began publicly reporting American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) surgical outcomes on its public reporting website, Hospital Compare. Participation in this CMS-NSQIP initiative is voluntary. Our objective was to compare CMS-NSQIP participating hospitals with ACS NSQIP hospitals that elected not to participate.

STUDY DESIGN: Hospital Compare and American Hospital Association Annual Survey data were merged to compare CMS-NSQIP participants with nonparticipants. Regression models were developed to assess predictors of participation and to assess if hospitals differed on 32 process, 10 patient experience (Hospital Consumer Assessment of HealthCare Providers and Systems [HCAHPS]), and 16 outcomes (Hospital Compare and Agency for Healthcare Research Quality) measures. Additionally, performance on 2 waves of publicly reported ACS NSQIP surgical outcomes measures was compared.

RESULTS: Of the 452 ACS NSQIP hospitals, 80 (18%) participated in CMS-NSQIP public reporting. Participating hospitals had more beds, admissions, operations, and were more often accredited (Commission on Cancer and the Council of Teaching Hospitals [COTH] [$p < 0.05$]). Only COTH membership remained significant in adjusted analyses (odds ratio 2.45, 95% CI 1.12 to 5.35).

Hospital performance on process, HCAHPS, and outcomes measures were not associated with CMS-NSQIP participation for 54 of 58 measures examined. Hospitals with "better-than-average" performance were more likely to publicly report the Elderly Surgery measure ($p < 0.05$). In wave 2, an increased proportion of new participants reported "worse-than-average" outcomes.

CONCLUSIONS: There were few measurable differences between CMS-NSQIP participating and nonparticipating hospitals. The decision to voluntarily publicly report may be related to the hospital's culture of quality improvement and transparency. Copyright 2014 American College of Surgeons.

25. Validation of new readmission data in the American College of Surgeons National Surgical Quality Improvement Program.

Sellers MM. Merkow RP. Halverson A. Hinami K. Kelz RR. Bentrem DJ. Bilimoria KY.

Journal of the American College of Surgeons. 216(3):420-7, 2013 Mar.

BACKGROUND: Hospital readmissions are gathering increasing attention as a measure of health care quality and as a cost-saving target. The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) recently began collecting data related to 30-day postoperative readmissions. Our objectives were to assess the accuracy of the ACS NSQIP readmission variable by comparison with the medical record, and to evaluate the readmission variable against administrative data.

STUDY DESIGN: Readmission data captured in ACS NSQIP at a single academic institution between January and December 2011 were compared with data abstracted from the medical record and administrative data.

RESULTS: Of 1,748 cases captured in ACS NSQIP, 119 (6.8%) had an all-cause readmission event identified, and ACS NSQIP had very high agreement with chart review for identifying all-cause readmission events (= 0.98). For 1,110 inpatient cases successfully matched with administrative data, agreement with chart review for identifying all-cause readmissions was also very high (= 0.97). For identifying unplanned readmission events, ACS NSQIP had good agreement with chart review (= 0.67). Overall, agreement with chart review on cause of readmission was higher for ACS NSQIP (= 0.75) than for administrative data (= 0.46).

CONCLUSIONS: The ACS NSQIP accurately captured all-cause and unplanned readmission events and had good agreement with the medical record with respect to cause of readmission. Administrative data accurately captured all-cause readmissions, but could not identify unplanned readmissions and less consistently agreed with chart review on cause. The granularity of clinically collected data offers tremendous advantages for directing future quality efforts targeting surgical readmission.

26. American College of Surgeons National Surgical Quality Improvement Program Pediatric: a beta phase report.

Bruny JL. Hall BL. Barnhart DC. Billmire DF. Dias MS. Dillon PW. Fisher C. Heiss KF. Hennrikus WL. Ko CY. Moss L. Oldham KT. Richards KE. Shah R. Vinocur CD. Ziegler MM.

Journal of Pediatric Surgery. 48(1):74-80, 2013 Jan.

PURPOSE: The American College of Surgeons (ACS) National Surgical Quality Improvement Program Pediatric (NSQIP-P) expanded to beta phase testing with the enrollment of 29 institutions. Data collection and analysis were aimed at program refinement and development of risk-adjusted models for inter-institutional comparisons.

METHODS: Data from the first full year of beta-phase NSQIP-P were analyzed. Patient accrual used ACS-NSQIP methodology tailored to pediatric specialties. Preliminary risk adjusted modeling for all pediatric and neonatal operations and pediatric (excluding neonatal) abdominal operations was performed for all cause morbidity (other than death) and surgical site infections (SSI) using hierarchical logistic regression methodology and eight predictor variables. Results were expressed as odds ratios with 95% confidence intervals.

RESULTS: During calendar year 2010, 29 institutions enrolled 37,141 patients. 1644 total CPT codes were entered, of which 456 accounted for 90% of the cases. 450 codes were entered only once (1.2% of cases). For all cases, overall mortality was 0.25%, overall morbidity 7.9%, and the SSI rate 1.8%. For neonatal cases, mortality was 2.39%, morbidity 18.7%, and the SSI rate 3%. For the all operations model, risk-adjusted morbidity institutional odds ratios ranged 0.48-2.63, with 9/29 hospitals categorized as low outliers and 9/29 high outliers, while risk-adjusted SSI institutional odds ratios ranged 0.36-2.04, with 2/29 hospitals low outliers and 7/29 high outliers.

CONCLUSION: This report represents the first risk-adjusted hospital-level comparison of surgical outcomes in infants and children using NSQIP-P data. Programmatic and analytic modifications will improve the impact of this program as it moves into full implementation. These results indicate that NSQIP-P has the potential to serve as a model for determining risk-adjusted outcomes in the neonatal and pediatric population with the goal of developing quality improvement initiatives for the surgical care of children. Copyright 2013 Elsevier Inc. All rights reserved.

27. The power of the National Surgical Quality Improvement Program--achieving a zero pneumonia rate in general surgery patients.

Fuchshuber PR. Greif W. Tidwell CR. Klemm MS. Frydel C. Wali A. Rosas E. Clopp MP. *Permanente Journal*. 16(1):39-45, 2012.

The National Surgical Quality Improvement Program (NSQIP) of the American College of Surgeons provides risk-adjusted surgical outcome measures for participating hospitals that can be used for performance improvement of surgical mortality and morbidity. A surgical clinical nurse reviewer collects 135 clinical variables including preoperative risk factors, intraoperative variables, and 30-day postoperative mortality and morbidity outcomes for patients undergoing major surgical procedures. A report on mortality and complications is prepared twice a year. This article summarizes briefly the history of NSQIP and how its report on surgical outcomes can be used for performance improvement within a hospital system. In particular, it describes how to drive performance improvement with NSQIP data using the example of postoperative respiratory complications--a major factor of postoperative mortality. In addition, this article explains the benefit of a collaborative of several participating NSQIP hospitals and describes how to develop a "playbook" on the basis of an outcome improvement project.

28. The role of Surgical Champions in the American College of Surgeons National Surgical Quality Improvement Program--a national survey.

Raval MV. Bentrem DJ. Eskandari MK. Ingraham AM. Hall BL. Randolph B. Ko CY. Morton JM. *Journal of Surgical Research*. 166(1):e15-25, 2011 Mar.

BACKGROUND: The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) empowers surgeons and medical centers to reliably collect, analyze, and act on clinically collected outcomes data. How individual ACS NSQIP leaders designated as Surgeon Champions (SC) utilize the ACS NSQIP at the hospital level and the obstacles they encounter are not well studied.

MATERIALS AND METHODS: All SC representing the 236 hospitals participating in the ACS NSQIP were invited to complete a survey designed to assess the role of the SC, data use, continuous quality improvement (CQI) efforts, CQI culture, and financial implications.

RESULTS: We received responses from 109 (46.2%) SC. The majority (72.5%) of SC were not compensated for their CQI efforts. Factors associated with demonstrable CQI efforts included longer duration of participation in the program, frequent meetings with clinical reviewers, frequent presentation of data to administration, compensation for Surgical Champion efforts and providing individual surgeons with feedback (all $P < 0.05$). Almost all SC stated ACS NSQIP data improved the quality of care that patients received at the hospital level (92.4%) and that the ACS NSQIP provided data that could not be obtained by other sources (95.2%). All SCs considered future funding for participation in the ACS NSQIP secure.

CONCLUSIONS: Active use of ACS NSQIP data provide SC with demonstrable CQI by regularly reviewing data, having frequent interaction with clinical reviewers, and frequently sharing data with hospital administration and colleagues. SC thus play a key role in successful quality improvement at the hospital level. Copyright 2011 Elsevier Inc. All rights reserved.

29. Improving American College of Surgeons National Surgical Quality Improvement Program risk adjustment: incorporation of a novel procedure risk score.

Raval MV. Cohen ME. Ingraham AM. Dimick JB. Osborne NH. Hamilton BH. Ko CY. Hall BL. *Journal of the American College of Surgeons*. 211(6):715-23, 2010 Dec.

BACKGROUND: Risk-adjusted evaluation is a key component of the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP). The purpose of this study was to improve standard ACS NSQIP risk adjustment using a novel procedure risk score.

STUDY DESIGN: Current Procedural Terminology codes (CPTs) represented in ACS NSQIP data were assigned to 136 procedure groups. Log odds predicted risk from preliminary logistic regression modeling generated a continuous risk score for each procedure group, used in subsequent modeling. Appropriate subsets of 271,368 patients in the 2008 ACS NSQIP were evaluated using logistic models for overall 30-day morbidity, 30-day mortality, and surgical site infection (SSI). Models were compared when including either work Relative Value Unit (RVU), RVU and the standard ACS NSQIP CPT range variable (CPT range), or RVU and the newly constructed CPT risk score (CPT risk), plus routine ACS NSQIP predictors.

RESULTS: When comparing the CPT risk models with the CPT range models for morbidity in the overall general and vascular surgery dataset, CPT risk models provided better discrimination through higher c statistics at earlier steps (0.81 by step 3 vs 0.81 by step 46), more information through lower Akaike's information criterion (127,139 vs 130,019), and improved calibration through a smaller Hosmer-Lemeshow chi-square statistic (48.76 vs 116.79). Improved model characteristics of CPT risk over CPT range were most apparent for broader patient populations and outcomes. The CPT risk and standard CPT range models were moderately consistent in identification of outliers as well as assignment of hospitals to quality deciles (weighted kappa > 0.870).

CONCLUSIONS: Information from focused, clinically meaningful CPT procedure groups improves the risk estimation of ACS NSQIP models. Copyright 2010 American College of Surgeons.

Published by

30. Quality improvement in surgery: the American College of Surgeons National Surgical Quality Improvement Program approach. [Review]

Ingraham AM. Richards KE. Hall BL. Ko CY.

Advances in Surgery. 44:251-67, 2010.

The history and development of the NSQIP, from its inception in the Veterans Administration Health System to its implementation within the private sector sponsored by the ACS, documents the growth of a program that has substantially improved the quality of surgical care and has had a considerable influence on the culture of quality improvement in the profession. The success of the ACS NSQIP is the result of providing hospitals with rigorous, clinical data, networking opportunities, and resources to improve their risk-adjusted outcomes. In this manner, the ACS NSQIP challenges its hospitals and health care providers to continually improve the care they provide. In addition to reducing the complications and mortality experienced by patients after surgical procedures, hospitals that participate in the ACS NSQIP have seen the financial rewards of their quality improvement efforts. Continued growth of the ACS NSQIP will facilitate achievement of the primary goal surrounding the current health care reform debate: efficient, high-quality care.

31. Preliminary NSQIP results: a tool for quality improvement.

Stachler RJ. Yaremchuk K. Ritz J.

Otolaryngology - Head & Neck Surgery. 143(1):26-30, 30.e1-3, 2010 Jul.

OBJECTIVE: To utilize National Surgical Quality Improvement Program (NSQIP) data to evaluate patient outcomes in otolaryngology-head and neck surgery.

STUDY DESIGN: Retrospective medical chart abstraction of patients undergoing major surgical procedures in the inpatient and outpatient setting.

SETTING: Academic/teaching hospitals with more than 500 beds.

SUBJECTS AND METHODS: The American College of Surgeons NSQIP collects data on 135 variables including preoperative risk factors, intraoperative variables, and 30-day-postoperative mortality and morbidity outcomes for patients undergoing major surgical procedures in the inpatient and outpatient setting. As of August 2008, there are currently 47 hospitals submitting data for otolaryngology-head and neck surgery.

RESULTS: Opportunities for improvement were identified in respiratory, wound, and venothromboembolic (VTE) occurrences. Implementation of a standardized VTE and perioperative protocol resulted in a decreased length of stay and observed-to-expected (O/E) morbidity and mortality for all surgical services.

CONCLUSION: NSQIP reports form the basis for quality improvement with targeted interventions in areas of concern that result in changes in patient care processes. The reports are composed of outcomes-based, risk-adjusted data that are submitted by participating hospitals and have recently included data for otolaryngology-head and neck surgery. Actions taken based on NSQIP data demonstrate improvements in patient morbidity and mortality, decreased length of stay, and decreased hospital costs. In a time of increased scrutiny of health care costs and outcomes, NSQIP is an important tool for surgeons to improve quality and decrease costs. 2010 American Academy of Otolaryngology-Head and Neck Surgery Foundation. Published by Mosby, Inc. All rights reserved.

32. Toward robust information: data quality and inter-rater reliability in the American College of Surgeons National Surgical Quality Improvement Program.

Shiloach M. Frencher SK Jr. Steeger JE. Rowell KS. Bartzokis K. Tomeh MG. Richards KE. Ko CY. Hall BL.

Journal of the American College of Surgeons. 210(1):6-16, 2010 Jan.

BACKGROUND: Data used for evaluating quality of medical care need to be of high reliability to ensure valid quality assessment and benchmarking. The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) has continually emphasized the collection of highly reliable clinical data through its program infrastructure.

STUDY DESIGN: We provide a detailed description of the various mechanisms used in ACS NSQIP to assure collection of high quality data, including training of data collectors (surgical clinical reviewers) and ongoing audits of data reliability. For the 2005 through 2008 calendar years, inter-rater reliability was calculated overall and for individual variables using percentages of agreement between the data collector and the auditor. Variables with > 5% disagreement are flagged for educational efforts to improve accurate collection. Cohen's kappa was estimated for selected variables from the 2007 audit year.

RESULTS: Inter-rater reliability audits show that overall disagreement rates on variables have fallen from 3.15% in 2005 (the first year of public enrollment in ACS NSQIP) to 1.56% in 2008. In addition, disagreement levels for individual variables have continually improved, with 26 individual variables demonstrating > 5% disagreement in 2005, to only 2 such variables in 2008. Estimated kappa values suggest substantial or almost perfect agreement for most variables.

CONCLUSIONS: The ACS NSQIP has implemented training and audit procedures for its hospital participants that are highly effective in collecting robust data. Audit results show that data have been reliable since the program's inception and that reliability has improved every year. Copyright (c) 2010

33. Missing data in the American College of Surgeons National Surgical Quality Improvement Program are not missing at random: implications and potential impact on quality assessments.

Hamilton BH. Ko CY. Richards K. Hall BL.

Journal of the American College of Surgeons. 210(2):125-139.e2, 2010 Feb.

BACKGROUND: Studying risk-adjusted outcomes in health care relies on statistical approaches to handling missing data. The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) provides risk-adjusted assessments of surgical programs, traditionally imputing certain missing data points using a single round of multivariable imputation. Such imputation assumes that data are missing at random-without systematic bias-and does not incorporate estimation uncertainty. Alternative approaches, including using multiple imputation to incorporate uncertainty or using an indicator of missingness, can enhance robustness of evaluations.

STUDY DESIGN: One year of de-identified data from the ACS NSQIP, representing 117 institutions and 106,113 patients, was analyzed. Using albumin variables as the missing data modeled, several imputation/adjustment models were compared, including the traditional NSQIP imputation, a new single imputation, a multiple imputation, and use of a missing indicator.

RESULTS: Coefficients for albumin values changed under new single imputation and multiple imputation approaches. Multiple imputation resulted in increased standard errors, as expected. An indicator of missingness was highly explanatory, disproving the missing-at-random assumption. The effects of changes in approach differed for different outcomes, such as mortality and morbidity, and effects were greatest in smaller datasets. However, ultimate changes in patient risk assessment and institutional assessment were minimal.

CONCLUSIONS: Newer statistical approaches to modeling missing (albumin) values result in noticeable statistical distinctions, including improved incorporation of imputation uncertainty. In addition, the missing-at-random assumption is incorrect for albumin. Despite these findings, effects on institutional assessments are small. Although effects can be most important with smaller datasets, the current approach to imputing missing values in the ACS NSQIP appears reasonably robust.

34. Risk adjustment in the American College of Surgeons National Surgical Quality Improvement Program: a comparison of logistic versus hierarchical modeling.

Cohen ME. Dimick JB. Bilimoria KY. Ko CY. Richards K. Hall BL.

Journal of the American College of Surgeons. 209(6):687-93, 2009 Dec.

BACKGROUND: Although logistic regression has commonly been used to adjust for risk differences in patient and case mix to permit quality comparisons across hospitals, hierarchical modeling has been advocated as the preferred methodology, because it accounts for clustering of patients within hospitals. It is unclear whether hierarchical models would yield important differences in quality assessments compared with logistic models when applied to American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) data. Our objective was to evaluate differences in logistic versus hierarchical modeling for identifying hospitals with outlying outcomes in the ACS-NSQIP.

STUDY DESIGN: Data from ACS-NSQIP patients who underwent colorectal operations in 2008 at hospitals that reported at least 100 operations were used to generate logistic and hierarchical prediction models for 30-day morbidity and mortality. Differences in risk-adjusted performance (ratio of observed-to-expected events) and outlier detections from the two models were compared.

RESULTS: Logistic and hierarchical models identified the same 25 hospitals as morbidity outliers (14 low and 11 high outliers), but the hierarchical model identified 2 additional high outliers. Both

models identified the same eight hospitals as mortality outliers (five low and three high outliers). The values of observed-to-expected events ratios and p values from the two models were highly correlated. Results were similar when data were permitted from hospitals providing < 100 patients. **CONCLUSIONS:** When applied to ACS-NSQIP data, logistic and hierarchical models provided nearly identical results with respect to identification of hospitals' observed-to-expected events ratio outliers. As hierarchical models are prone to implementation problems, logistic regression will remain an accurate and efficient method for performing risk adjustment of hospital quality comparisons.

35. Implementation of the National Surgical Quality Improvement Program: critical steps to success for surgeons and hospitals.

Velanovich V. Rubinfeld I. Patton JH Jr. Ritz J. Jordan J. Dulchavsky S.

American Journal of Medical Quality. 24(6):474-9, 2009 Nov-Dec.

The National Surgical Quality Improvement Program (NSQIP), as administered by the American College of Surgeons, became available to private sector hospitals across the United States in 2004. The program works to improve surgical outcomes by providing high-quality, risk-adjusted data to surgeons at a given hospital to stimulate discussion and define target areas for improvement. Although the NSQIP began in the early 1990s with Veterans Administration hospitals and expanded to private sector hospitals nearly 5 years ago, the "how to" process for NSQIP implementation has been left to individual institutions to manage on their own. The NSQIP was instituted at a large tertiary hospital in 2005, identifying through experience 12 critical steps to help surgeons and hospitals implement the NSQIP.

36. Fifteen years of the National Surgical Quality Improvement Program in review.

Itani KM.

American Journal of Surgery. 198(5 Suppl):S9-S18, 2009 Nov.

Since 1994, the National Surgical Quality Improvement Program (NSQIP) has become a tool for the study of outcomes in surgery. Through carefully designed studies, patient risk factors, structures, and processes of care and their impact on various outcomes were carefully described within many specialties and subspecialties of surgery. "Fifteen years of NSQIP" is a celebration of the work of Shukri Khuri and his colleagues during this time frame. By summarizing their extensive contributions, a perspective is given as to the impact and breadth of their observations and recommendations on quality improvement for specific operations in various specialties under various conditions. A total of 128 articles published in the peer-reviewed literature dealing mostly with findings from the Veterans Affairs (VA) hospital system are summarized.

37. The National Surgical Quality Improvement Program: learning from the past and moving to the future.

Hammermeister K.

American Journal of Surgery. 198(5 Suppl):S69-73, 2009 Nov.

The National Surgical Quality Improvement Program (NSQIP) has achieved remarkable success over the 15 years of its existence, initially in the Veterans Health Administration and more recently in private and US Department of Defense hospitals. However, the NSQIP is at a critical juncture because of the cost and other limitations of data collection largely by manual chart abstraction. A potential solution is the documentation of care by surgical teams using the NSQIP data set as the foundation for standardized data that can be reused electronically for multiple other purposes, such as discharge abstracts, billing, and other Centers for Medicare and Medicaid Services and insurer requirements for data. It is likely that the innovative design of portions of the electronic medical

record will be time efficient and acceptable to surgical care providers once they experience its advantages.

38. Assessing surgical quality using administrative and clinical data sets: a direct comparison of the University HealthSystem Consortium Clinical Database and the National Surgical Quality Improvement Program data set.

Davenport DL. Holsapple CW. Conigliaro J.

American Journal of Medical Quality. 24(5):395-402, 2009 Sep-Oct.

The use of "clinical" versus "administrative" data sets for health care quality assessment continues to be debated. This study directly compares the University HealthSystem Consortium Clinical Database (UHC CDB) and the National Surgical Quality Improvement Program (NSQIP) in terms of their assessment of complications and death for 26 322 surgery patients using analyses of variance, correlation, and multivariable logistic regression. The NSQIP had more variables with significant correlation with outcomes. The NSQIP was better at predicting death (c-index 0.94 vs 0.90, $P < .05$) and complications (c-index 0.78 vs 0.76, $P = .07$), especially for higher risk patients. The UHC CDB missed and misclassified several major complications. The data sets are similar in their explanatory power relative to outcomes, but the clinical data set is better, particularly at identifying higher risk patients and specific complications. It should prove more useful for initiating and monitoring clinical process improvements because of more clinically relevant variables.

39. Surrounded by quality metrics: what do surgeons think of ACS-NSQIP?

Neuman HB. Michelassi F. Turner JW. Bass BL.

Surgery. 145(1):27-33, 2009 Jan.

BACKGROUND: In an era of proliferating systems of quality assessment, surgeon confidence in metric tools is essential for successful initiatives in quality improvement. We evaluated surgeons' awareness and attitudes about ACS-NSQIP, which is the only national, surgeon-developed, risk-adjusted, system of surgical outcome assessment.

METHODS: A 33-item survey instrument was constructed and content validity established through content expert review; test-retest reliability was assessed (weighted-kappa = 0.72). Survey administration occurred in three institutions with varying ACS-NSQIP experience. Summary statistics were generated and subgroup analyses performed (Fisher's exact test).

RESULTS: One-hundred and eight surgeons participated. Practice experience varied (27% residents, 33% < 10, 12% 10-20, and 28% > 20 years). Seventy-two percent had fellowship training. Surgeons were familiar with ACS-NSQIP structure, including prospective data collection (70%), case-sampling (63%), and reporting as observed/expected ratios (83%). Surgeons knew some collected data-points but misidentified EKG-findings of MI (67%), surgeon case-experience (41%), and anastomotic dehiscence (79%). Most felt ACS-NSQIP would improve quality of care (79%) and identify areas for improvement (92%). Surgeons were less confident regarding utility at an individual level, with only 46% believing surgeon-specific outcomes should be reported. Few thought ACS-NSQIP data should be available publicly (45%), used for marketing (26%), or direct pay-for-performance (24%). Reservations were most pronounced among surgeons with institutional ACS-NSQIP experience.

CONCLUSION: While surgeons accept ACS-NSQIP at an institutional level, skepticism remains surrounding measurement of individual outcomes and public reporting. Surgeons at institutions with a longer duration of experience with ACS-NSQIP tended to be more cynical about potential data applications. Ongoing education and assessment of surgeons' perceptions of quality improvement initiatives is necessary to ensure surgeons remain engaged actively in determining how quality of care data is measured and utilized.

40. The NSQIP: a new frontier in surgery. [Review] [11 refs]

Khuri SF.

Surgery. 138(5):837-43, 2005 Nov.

[Journal Article. Review]