## Title
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## Journal
Annals of Surgery, 260(4)

## ISSN
0003-4932

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## Publication Date
2014-10-01

## DOI
10.1097/sla.0000000000000931

Peer reviewed

# Measuring Risk-Adjusted Value Using Medicare and ACS-NSQIP

## *Is High-Quality, Low-Cost Surgical Care Achievable Everywhere?*

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**Objective:** To evaluate the relationship between risk-adjusted cost and quality for colectomy procedures and to identify characteristics of "high value" hospitals (high quality, low cost).

**Background:** Policymakers are currently focused on rewarding high-value health care. Hospitals will increasingly be held accountable for both quality and cost.

**Methods:** Records (2005–2008) for all patients undergoing colectomy procedures in the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) were linked to Medicare inpatient claims. Cost was derived from hospital payments by Medicare. Quality was derived from the occurrence of 30-day postoperative major complications and/or death as recorded in ACS-NSQIP. Risk-adjusted cost and quality metrics were developed using hierarchical multivariable modeling, consistent with a National Quality Forum–endorsed colectomy measure.

**Results:** The study population included 14,745 colectomy patients in 169 hospitals. Average hospitalization cost was $21,350 (SD $20,773, median $16,092, interquartile range $14,341–$24,598). Thirty-four percent of patients had a postoperative complication and/or death. Higher hospital quality was significantly correlated with lower cost (correlation coefficient 0.38, $P < 0.001$). Among hospitals classified as high quality, 52% were found to be low cost (representing highest value hospitals) whereas 14% were high cost ($P = 0.001$). Forty-one percent of low-quality hospitals were high cost. Highest "value" hospitals represented a mix of teaching/nonteaching affiliation, small/large bed sizes, and regional locations.

**Conclusions:** Using national ACS-NSQIP and Medicare data, this study reports an association between higher quality and lower cost surgical care. These results suggest that high-value surgical care is being delivered in a wide spectrum of hospitals and hospital types.

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Disclosure: E.H.L.'s time was supported by the VA Health Services Research and Development program (RWJ 65-020) and the American College of Surgeons through the Robert Wood Johnson Foundation Clinical Scholars Program. This study was funded by a contract from the Centers for Medicare and Medicaid Services. For the remaining authors, none were declared.

Presented at the 134th Annual Meeting of the American Surgical Association, April 10–12, 2014, Boston, MA.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.annalsofsurgery.com).

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ISSN: 0003-4932/14/26004-0668

DOI: 10.1097/SLA.0000000000000931

**Keywords:** colectomy, cost, Medicare, NSQIP, quality, surgery, value

(*Ann Surg* 2014;260:668–679)

Health care costs currently consume 18% of the US gross domestic product, and this percentage is expected to rise to 25% by 2025.[1] Despite spending as much as twice per capita on health care compared to other industrialized countries, the Institute of Medicine reports that the US ranks poorly for health care quality.[2] The Affordable Care Act (ACA) includes provisions to address the high cost and low quality of our health care system through the implementation of public reporting and pay for performance policies that reward or penalize hospitals and physicians based on their performance on a variety of measures, including measures of quality, cost, and patient satisfaction.[3] In addition, the ACA authorized the use of Accountable Care Organizations, which are designed to improve quality and reduce the cost to Medicare of health care by incentivizing the delivery of efficient, coordinated care.[4] This intersection of high quality and low cost represents an emerging focus on identifying and maximizing value in health care.

Within surgery, colectomy procedures represent a prime target for initiatives aimed at improving value for Medicare. In 2011, approximately 140,000 colectomies were performed on Medicare beneficiaries nationwide at an estimated total cost of $3.5 billion.[5] In addition, colectomy procedures have relatively high rates of postoperative complications compared to other procedures.[6] Hospital performance for a risk-adjusted colectomy quality measure is currently publicly reported on Medicare's Hospital Compare Web site; however, a similar measure for the cost of colectomy procedures has not been developed to date.[7]

This study aimed to assess the cost to Medicare associated with colectomy procedures and to identify patient and hospital characteristics that contribute to differences in costs to Medicare between hospitals. In addition, we aimed to evaluate the relationship between the risk-adjusted cost to Medicare for a colectomy hospitalization and the risk-adjusted quality of colectomy care. We hypothesized that there would be an inverse relationship between quality and cost, with higher quality hospitals being more likely to be lower cost. Because of the multifactorial contributors to a hospital being higher cost, we did not expect this relationship to be strong. Finally, we aimed to identify characteristics of hospitals found to be "high value" (defined as *high quality* and *low cost*). Our overarching goal was to inform policy decisions regarding measuring and improving the value of surgical care.

## METHODS

### Data Sources and Study Population

The RAND Corporation institutional review board approved the study protocol. All analyses were performed using SAS version 9.2 software (SAS Institute, Inc, Cary, NC).

The primary data sources for this study were ACS-NSQIP and Medicare inpatient claims, which have been previously described.[8] Briefly, ACS-NSQIP is a validated, institution-based, multispecialty, surgical registry of patient risk factors and 30-day postoperative

outcomes. Hospital participation in ACS-NSQIP is voluntary, but requires a dedicated data abstractor who is trained to use strict variable definitions and collection methods. The sampling strategy includes collecting data for the first 40 cases performed within consecutive 8-day cycles. Data are abstracted from medical records and directly from the patient if insufficient data are available in records. Information in the database is de-identified. Hospitals are audited to ensure standardized data collection, with prior audit results demonstrating substantial or almost perfect agreement on the coding of most variables.[9–11] The 100% Medicare Provider Analysis and Review file (MedPAR) contains inpatient hospital final action stay records for Medicare beneficiaries assembled from claims submitted by hospitals for reimbursement. Hospitals are identifiable and each Medicare beneficiary has a unique identification number allowing for linkage of subsequent hospital visits.[12] As previously described, eligible patient-level records from ACS-NSQIP, years 2005 to 2008, were linked to Medicare inpatient claims records in MedPAR for the same years using indirect patient identifiers and a deterministic linkage algorithm. Agreement between ACS-NSQIP and MedPAR records on death during the primary hospitalization was excellent, supporting the validity of the linkage procedure.[13] Structural characteristics of hospitals in the study population were identified from the American Hospital Association 2013 Hospital Database.

Our study population was restricted to patients 65 years or older who underwent an inpatient colectomy procedure during the years studied, were entered into the ACS-NSQIP database, and for whom we were able to successfully link the ACS-NSQIP record to Medicare claims data. Colectomy cases were identified by *Current Procedural Terminology* (CPT) code (see Table, Supplemental Digital Content 1, available at http://links.lww.com/SLA/A612, which lists CPT codes included in study). We excluded patients for whom Medicare was not the primary payer (n = 3435). Hospitals with fewer than 20 cases were excluded because estimates for these hospitals are less reliable (n = 377 patients, 41 hospitals).

## Risk-Adjusted Quality for Colectomy Procedures

We used a National Quality Forum (NQF) endorsed risk-adjusted composite measure of surgical quality to identify high- and low-quality hospitals. This composite measure reflects hospital performance for serious complications and/or death occurring within 30 days after a colectomy procedure. This measure is entirely derived from ACS-NSQIP data. The outcome is a binary variable that includes any of the following occurrences: death, unplanned reoperation, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, deep venous thrombosis requiring therapy, sepsis, septic shock, deep incisional surgical site infection (SSI), organ space SSI, wound disruption (ie, fascial dehiscence), unplanned reintubation (without prior ventilator dependence), pneumonia (without pneumonia before surgery), pulmonary embolism, progressive renal insufficiency, acute renal failure (without preoperative renal failure/dialysis), or urinary tract infection.

A hierarchical multivariable logistic regression model was developed for the composite outcome of any serious complication or death. This approach accounts for clustering of patients within hospitals by allowing each hospital to have a different random intercept and is the standard approach for ACS-NSQIP quality measure modeling.[14] Consistent with the NQF measure, the following patient-level variables were included for case-mix adjustment: American Society of Anesthesiology (ASA) class, functional status before surgery, indication for surgery, wound class, and whether or not the case was emergent. Missing values of ASA class were imputed by hospital using the hot deck method. Indication for surgery was derived from *International Classification of Diseases, Ninth Edition* codes, which were classified into 10 groups. Dummy variables for colectomy CPT codes were included for procedure-mix adjustment. The hospital random intercept, or odds ratio, derived from the model was used to determine individual hospital performance for the quality measure. This odds ratio estimates the odds of a patient having the outcome at the specified hospital versus the odds of having the outcome at a theoretical "average" hospital, adjusted for the clinical variables included in the model.

## Risk-Adjusted Cost for Colectomy Procedures

Our primary outcome of interest was cost to Medicare for a hospitalization for a colectomy procedure. As such, the cost of a hospitalization was measured by the dollar amount paid to the hospital by Medicare after removing geographic and policy adjustments. This dollar amount is determined through the inpatient prospective payment system, which is intended to motivate the delivery of efficient patient care and prevent overutilization of services.[15] Under this system, each hospitalization is categorized into a diagnosis-related group (DRG). Each DRG in turn carries a specific payment weight, which is derived from the average resources used to treat Medicare patients with that DRG. The DRG relative weight is used to calculate a payment for the hospitalization that is above or below the annually set base operating and capital payment rates, which are then adjusted for geographic differences in cost of living and labor costs. Policy adjustments are applied to account for additional costs incurred by hospitals that teach medical trainees ("indirect medical education payment") and/or serve a low-income patient population ("disproportionate share payment"). Finally, hospitals may request additional payment for hospitalizations that are extraordinary costly ("outlier payment").[15] For this study, we calculated the cost of a colectomy hospitalization using the DRG assigned to the hospital stay, publicly available annual DRG relative weights and base operating and capital payment rates, and any outlier payments made to the hospital (as reported in MedPAR). In addition, the market basket index was used to inflate all costs to 2009 dollars. Geographic and policy adjustments were omitted to more specifically evaluate costs for clinical care.

$$\text{Cost to Medicare for a colectomy hospitalization} = [(\text{DRG weight}) \times (\text{base operating} + \text{capital rates}) + \text{outlier payment}] \times \text{MBI}$$

Costs were calculated for each patient and then ranked and split into 3 groups. Because of frequently occurring values for costs, these groups did not contain equal numbers of patients: 5854 patients (39.7%) in lowest cost group, 4497 patients (30.5%) in middle cost group, and 4394 patients (29.8%) in highest cost group. Using ACS-NSQIP data, rates of preoperative clinical characteristics and postoperative complications occurring before and after discharge were calculated and compared between the 3 groups with $\chi^2$ tests. In addition, costs were averaged at the hospital level and then ranked and split into 3 groups: 55 hospitals (32.9%) in the lowest average cost group, 56 hospitals (33.5%) in the middle average cost group, and 56 hospitals (33.5%) in the highest average cost group. Using the American Hospital Association 2013 Hospital Database, hospital structural characteristics (region, bed size, teaching affiliation, etc) were compared between the 3 groups with $\chi^2$ tests.

Hierarchical multivariable generalized linear regression models were developed to identify the risk-adjusted association between patient risk factors and cost. Because cost has a right-skewed distribution, we used a log link and gamma distribution. The first model included only preoperative risk factors, whereas the second model additionally included postoperative complications occurring within 30 days of surgery and before discharge from the primary hospitalization. To rank hospital performance for risk-adjusted cost, a third model was developed using the same variables for case-mix and

**TABLE 1.** Preoperative Clinical Characteristics for Patients Undergoing Colectomy Procedures in 2005-2008 and Associated Percentages of Patients Who Are in the Lowest, Middle, or Highest Groups for Cost to Medicare

| | No. Colectomy Patients (% of Study Sample) | Percentage of Patients in Lowest Cost Group (Mean $12,071; Median $13,334) | Percentage of Patients in Mid Cost Group (Mean $17,578; Median $16,092) | Percentage of Patients in Highest Cost Group (Mean $37,561; Median $25,059) | *P* |
|---|---|---|---|---|---|
| Total | 14,745 | 39.7% | 30.5% | 29.8% | |
| Procedure | | | | | |
| Laparoscopic | 4296 (29.1) | 56.2 | 30.0 | 13.8 | <0.001 |
| Open | 10,449 (70.9) | 32.9 | 30.7 | 36.4 | |
| Diagnosis | | | | | |
| Benign neoplasm | 1852 (12.6) | 62.9 | 28.0 | 9.2 | <0.001 |
| Diverticulitis | 2132 (14.5) | 33.7 | 31.2 | 35.1 | |
| Fistula | 285 (1.9) | 31.2 | 39.0 | 29.8 | |
| Hemorrhage | 113 (0.8) | 16.8 | 23.9 | 59.3 | |
| Infectious colitis | 308 (2.1) | 8.1 | 15.6 | 76.3 | |
| Malignancy | 6985 (47.4) | 46.1 | 35.1 | 18.8 | |
| Crohn disease/UC | 223 (1.5) | 26.0 | 26.5 | 47.5 | |
| Obstruction/perforation | 1365 (9.3) | 13.0 | 25.9 | 61.0 | |
| Other | 981 (6.7) | 34.9 | 20.8 | 44.3 | |
| Vascular insufficiency | 501 (3.4) | 7.2 | 13.0 | 79.8 | |
| Age category, yrs | | | | | |
| 65–74 | 6238 (42.3) | 44.4 | 29.8 | 25.8 | <0.001 |
| 75–84 | 6248 (42.4) | 37.9 | 30.8 | 31.4 | |
| >84 | 2259 (15.3) | 31.5 | 32.0 | 36.5 | |
| Sex | | | | | |
| Female | 8343 (56.6) | 40.1 | 30.7 | 29.3 | 0.245 |
| Male | 6402 (43.4) | 39.2 | 30.3 | 30.5 | |
| Admission source | | | | | |
| Home | 13,598 (92.2) | 41.8 | 31.5 | 26.8 | <0.001 |
| Acute care facility | 545 (3.7) | 12.5 | 19.5 | 68.1 | |
| Chronic care facility | 529 (3.6) | 15.5 | 18.0 | 66.5 | |
| Other | 73 (0.5) | 26.0 | 28.8 | 45.2 | |
| ASA category | | | | | |
| I and II | 4522 (30.7) | 54.0 | 32.9 | 13.2 | <0.001 |
| III | 8026 (54.4) | 38.6 | 32.8 | 28.6 | |
| IV and V | 2197 (14.9) | 14.1 | 17.3 | 68.6 | |
| Functional status | | | | | |
| Independent | 12,251 (83.1) | 44.8 | 32.8 | 22.5 | <0.001 |
| Partially dependent | 1700 (11.5) | 18.2 | 23.5 | 58.3 | |
| Fully dependent | 794 (5.4) | 7.2 | 10.7 | 82.1 | |
| Smoker | 1548 (10.5) | 34.2 | 29.1 | 36.7 | <0.001 |
| >2 drinks per day alcohol | 472 (3.2) | 37.3 | 32.6 | 30.1 | 0.334 |
| Body mass index category (kg/m$^2$) | | | | | |
| Underweight (<18.5) | 470 (3.2) | 30.2 | 30.0 | 39.8 | <0.001 |
| Normal (18.5–24.9) | 5245 (35.6) | 38.6 | 30.8 | 30.6 | |
| Overweight (25–29.9) | 5101 (34.6) | 41.6 | 30.4 | 28.0 | |
| Obese I (30–34.9) | 2513 (17.0) | 41.2 | 30.2 | 28.7 | |
| Obese II (35–39.9) | 928 (6.3) | 39.3 | 32.2 | 28.5 | |
| Obese III (>39.9) | 488 (3.3) | 32.4 | 28.3 | 39.3 | |
| Diabetes | | | | | |
| None | 11,912 (80.8) | 40.4 | 31.1 | 28.5 | <0.001 |
| Oral medication | 1953 (13.3) | 39.7 | 29.7 | 30.6 | |
| Insulin dependent | 880 (6.0) | 29.1 | 24.7 | 46.3 | |
| Dyspnea | | | | | |
| None | 11,935 (80.9) | 41.8 | 31.0 | 27.3 | <0.001 |
| Moderate exertion | 2274 (15.4) | 35.4 | 31.6 | 33.0 | |
| At rest | 536 (3.6) | 11.0 | 15.9 | 73.1 | |
| Ventilator dependent | 362 (2.5) | 2.5 | 7.2 | 90.3 | <0.001 |
| COPD | 1563 (10.6) | 24.3 | 25.7 | 50.0 | <0.001 |
| Recent myocardial infarction | 216 (1.5) | 17.1 | 18.1 | 64.8 | <0.001 |
| Congestive heart failure | 431 (2.9) | 13.2 | 17.6 | 69.1 | <0.001 |
| Hypertension requiring medication | 10,366 (70.3) | 37.8 | 30.4 | 31.8 | <0.001 |
| Renal failure | 307 (2.1) | 6.5 | 6.8 | 86.6 | <0.001 |
| Ascites | 447 (3.0) | 11.2 | 16.8 | 72.0 | <0.001 |

(*continued*)

**TABLE 1.** (*Continued*)

| | No. Colectomy Patients (% of Study Sample) | Percentage of Patients in Lowest Cost Group (Mean $12,071; Median $13,334) | Percentage of Patients in Mid Cost Group (Mean $17,578; Median $16,092) | Percentage of Patients in Highest Cost Group (Mean $37,561; Median $25,059) | *P* |
|---|---|---|---|---|---|
| Disseminated cancer | 709 (4.8) | 27.8 | 34.3 | 37.9 | <0.001 |
| Chemotherapy | 244 (1.7) | 21.3 | 33.2 | 45.5 | <0.001 |
| Radiotherapy | 300 (2.0) | 54.0 | 25.7 | 20.3 | <0.001 |
| >10% weight loss in last 6 mo | 878 (6.0) | 27.7 | 30.6 | 41.7 | <0.001 |
| Steroid use | 837 (5.7) | 21.4 | 24.9 | 53.8 | <0.001 |
| Bleeding disorder | 1409 (9.6) | 20.9 | 23.1 | 56.1 | <0.001 |
| Sepsis | | | | | <0.001 |
| None | 12,374 (83.9) | 45.2 | 33.2 | 21.6 | |
| Systemic inflammatory response | 1409 (9.6) | 15.1 | 20.7 | 64.2 | |
| Sepsis | 419 (2.8) | 7.4 | 16.0 | 76.6 | |
| Septic shock | 543 (3.7) | 3.3 | 6.1 | 90.6 | |
| Wound class | | | | | <0.001 |
| II: Clean-contaminated | 11,283 (76.5) | 45.9 | 33.0 | 21.1 | |
| III: Contaminated | 1594 (10.8) | 28.9 | 27.5 | 43.7 | |
| IV: Dirty | 1868 (12.7) | 111.2 | 18.5 | 70.3 | |
| Emergency case | 2852 (19.3) | 11.9 | 20.8 | 67.3 | <0.001 |

Preoperative clinical characteristics identified from ACS-NSQIP for patients who underwent colectomy procedures between the years 2005 and 2008. Costs were derived from Medicare inpatient claims data as described in the text.

COPD indicates chronic obstructive pulmonary disease.

procedure-mix adjustment as were included in the colectomy quality measure. The inverse-log transformed hospital random intercept derived from this third model was used to determine individual hospital performance. This number can be thought of as a *cost ratio* and reflects a specific hospital's average cost relative to that of a theoretical "average" hospital, adjusted for the clinical variables included in the model. For example, a hospital with a cost ratio of 2 on average received payments from Medicare that were 2 times higher than would be expected for their given patient population.

### Assessment of Value

Hospitals were ranked by their performance on each measure and split into 3 groups for comparison. For the quality measure, the lowest group reflects hospitals with lower risk-adjusted odds of serious complications and/or death than expected (ie, high quality). For the cost measure, the lowest group reflects hospitals with lower risk-adjusted cost ratios than expected (ie, low cost). Characteristics of *high-value* hospitals (defined as *high quality* and *low cost*) were determined using the American Hospital Association 2013 Hospital Database.

## RESULTS

The study sample included 14,745 Medicare patients who underwent an inpatient colectomy procedure from 169 hospitals. Table 1 lists demographic and preoperative clinical characteristics of the study population. The majority of colectomies were open procedures (71%) and the most frequent diagnoses were malignancy (47%) followed by diverticulitis (15%) and benign neoplasm (13%). The average cost for a colectomy hospitalization was $21,350 (SD $20,773) and the median cost was $16,092 (interquartile range $14,341–$24,598). Additional outlier payments above the DRG-based payment were made for 8.1% of hospitalizations (mean $25,072, SD $33,107, median $14,383).

Table 1 lists percentages of patients who were in the lowest, middle, or highest groups of raw cost, stratified by preoperative characteristics. The majority of patients undergoing laparoscopic procedures were in the lowest group for cost (56%), whereas a minority was in the highest cost group (14%). In contrast, patients undergoing open colectomy procedures were more evenly distributed among the cost groups (33%, 31%, and 36% in the lowest, mid, and highest cost groups, respectively). Among the diagnoses, benign neoplasm had the highest percentage of patients in the lowest cost group (63%), followed by malignancy (46%). The vascular insufficiency and infectious colitis diagnoses had the highest percentages of patients in the highest cost group (80% and 76%, respectively). Patients with greater preoperative clinical severity were generally more likely to be in the highest cost group.

The ACS-NSQIP 30-day postoperative complication rate for the study population was 33.5%; 66.5% of patients did not have a complication. The percentage of patients who had a postoperative complication occurred *before discharge* was 27%. Among patients with a postoperative complication occurring before discharge (any 1 or more of the complications studied), 64% were in the highest cost group, compared to 17% among patients without a postoperative complication before discharge ($P < 0.001$) (Table 2). There was an increasing graded relationship between the number of postoperative complications a patient had before discharge and the percentage of patients in the highest cost group. Of patients with any 1 postoperative complication occurring before discharge, 47% were in the highest cost group, and this percentage increased to 67%, 81%, and 90% for patients with any 2, any 3, or more than 3 postoperative complications occurring before discharge, respectively.

Each of the postoperative complications studied was associated with having a significantly higher percentage of patients in the highest cost group if the complication occurred before discharge (Table 2). For example, of the 5% of patients with postoperative pneumonia occurring before discharge, 81% were in the highest cost group. Similarly, of the 10% of patients with postoperative respiratory failure, 86% were in the highest cost group. Postoperative complications that occurred *after discharge* were generally associated with being in a lower cost group for the initial hospitalization. For example, only 16% of patients with a superficial SSI that occurred *after*

**TABLE 2.** Postoperative Complications Occurring Before and After Discharge Among Patients Undergoing Colectomy Procedures in 2005–2008 and Associated Percentages of Patients Who Are in the Lowest, Middle, or Highest Groups for Cost to Medicare

| | No. Colectomy Patients (% of Study Sample) | Percentage of Patients in Lowest Cost Group (Mean $12,071; Median $13,334) | Percentage of Patients in Mid Cost Group (Mean $17,578; Median $16,092) | Percentage of Patients in Highest Cost Group (Mean $37,561; Median $25,059) | *P* |
|---|---|---|---|---|---|
| Total | 14,745 | 39.7% | 30.5% | 29.8% | |
| No postoperative complications before discharge | 10,780 (73.1) | 48.7 | 34.0 | 17.3 | <0.001 |
| Any postoperative complication (≥1) before discharge | 3965 (26.9) | 15.1 | 21.0 | 63.8 | |
| Any 1 postoperative complication before discharge | 1850 (12.6) | 23.0 | 30.2 | 46.8 | <0.001 |
| Any 2 postoperative complications before discharge | 815 (5.5) | 14.7 | 18.3 | 67.0 | <0.001 |
| Any 3 postoperative complications before discharge | 580 (3.9) | 6.6 | 12.4 | 81.0 | <0.001 |
| Any ≥4 postoperative complications before discharge | 720 (4.9) | 2.2 | 7.5 | 90.3 | <0.001 |
| Any postoperative complication (≥1) occurring after discharge | 1411 (9.6) | 37.7 | 33.7 | 28.6 | <0.001 |
| Any postoperative complication (≥1) occurring after discharge without a complication before discharge | 978 (6.6) | 43.4 | 35.5 | 21.2 | <0.001 |
| No 30-day postoperative complications | 9802 (66.5) | 49.2 | 33.9 | 16.9 | <0.001 |
| Individual postoperative complications stratified by timing of occurrence | | | | | |
| Superficial SSI | | | | | <0.001 |
| Before discharge | 627 (4.3) | 21.9 | 32.2 | 45.9 | |
| After discharge | 514 (3.5) | 46.3 | 37.7 | 16.0 | |
| Deep SSI | | | | | |
| Before discharge | 152 (1.0) | 11.8 | 14.5 | 73.7 | <0.001 |
| After discharge | 95 (0.6) | 35.8 | 49.5 | 14.7 | |
| Organ-space SSI | | | | | |
| Before discharge | 341 (2.3) | 5.0 | 10.0 | 85.0 | <0.001 |
| After discharge | 145 (1.0) | 40.7 | 34.5 | 24.8 | |
| Dehiscence | | | | | |
| Before discharge | 217 (1.5) | 8.8 | 18.9 | 72.4 | <0.001 |
| After discharge | 78 (0.5) | 35.9 | 37.2 | 26.9 | |
| Pneumonia | | | | | |
| Before discharge | 790 (5.4) | 7.9 | 11.0 | 81.1 | <0.001 |
| After discharge | 71 (0.5) | 35.2 | 33.8 | 31.0 | |
| Respiratory failure | | | | | |
| Before discharge | 1460 (9.9) | 4.7 | 9.7 | 85.6 | <0.001 |
| After discharge | 52 (0.4) | 48.1 | 25.0 | 26.9 | |
| Pulmonary embolism | | | | | |
| Before discharge | 103 (0.7) | 12.6 | 14.6 | 72.8 | <0.001 |
| After discharge | 42 (0.3) | 50.0 | 28.6 | 21.4 | |
| Deep vein thrombosis | | | | | |
| Before discharge | 268 (1.8) | 9.7 | 11.6 | 78.7 | <0.001 |
| After discharge | 77 (0.5) | 37.7 | 32.5 | 29.9 | |
| Renal failure | | | | | |
| None | 14,338 (97.2) | 40.4 | 31.0 | 28.6 | |
| Acute renal failure | | | | | |
| Before discharge | 214 (1.5) | 1.4 | 8.4 | 90.2 | <0.001 |
| After discharge | 27 (0.2) | 44.4 | 33.3 | 22.2 | |

(*continued*)

**TABLE 2.** (*Continued*)

| | No. Colectomy Patients (% of Study Sample) | Percentage of Patients in Lowest Cost Group (Mean $12,071; Median $13,334) | Percentage of Patients in Mid Cost Group (Mean $17,578; Median $16,092) | Percentage of Patients in Highest Cost Group (Mean $37,561; Median $25,059) | *P* |
|---|---|---|---|---|---|
| Progressive renal failure | | | | | |
| Before discharge | 104 (0.7) | 12.5 | 15.4 | 72.1 | |
| After discharge | 62 (0.4) | 40.3 | 29.0 | 30.7 | |
| Urinary tract infection | | | | | |
| Before discharge | 522 (3.5) | 18.4 | 26.4 | 55.2 | <0.001 |
| After discharge | 210 (1.4) | 41.0 | 34.8 | 24.3 | |
| Stroke | | | | | |
| Before discharge | 87 (0.6) | 12.6 | 20.7 | 66.7 | <0.001 |
| After discharge | 27 (0.2) | 37.0 | 22.2 | 40.7 | |
| Cardiac arrest requiring CPR | | | | | |
| Before discharge | 188 (1.3) | 9.6 | 14.9 | 75.5 | <0.001 |
| After discharge | 18 (0.1) | 27.8 | 27.8 | 44.4 | |
| Myocardial infarction | | | | | |
| Before discharge | 81 (0.6) | 8.6 | 19.8 | 71.6 | <0.001 |
| After discharge | 10 (0.1) | 30.0 | 60.0 | 10.0 | |
| Bleeding requiring transfusion | | | | | |
| Before discharge | 155 (1.1) | 6.5 | 10.3 | 83.2 | <0.001 |
| After discharge | 5 (0.03) | 20.0 | 60.0 | 20.0 | |
| Sepsis | | | | | |
| None | 13,143 (89.1) | 43.0 | 32.2 | 24.8 | <0.001 |
| Sepsis | | | | | |
| Before discharge | 610 (4.1) | 12.1 | 19.8 | 68.0 | |
| After discharge | 156 (1.1) | 42.3 | 28.9 | 28.9 | |
| Septic shock | | | | | |
| Before discharge | 763 (5.2) | 5.0 | 10.4 | 84.7 | |
| After discharge | 73 (0.5) | 30.1 | 34.3 | 35.6 | |
| Unplanned return to operating room | 1129 (7.7) | 14.2 | 17.7 | 68.1 | <0.001 |
| Mortality | | | | | |
| Before discharge | 823 (5.6) | 7.2 | 11.9 | 80.9 | <0.001 |
| After discharge | 225 (1.5) | 18.2 | 23.1 | 58.7 | |

30-day postoperative complications identified from ACS-NSQIP for patients who underwent colectomy procedures between the years 2005 and 2008. Respiratory failure defined as unplanned intubation and/or on ventilator >48 hours. Costs were derived from Medicare inpatient claims data as described in the text.

CPR indicates cardiopulmonary resuscitation.

*discharge* were in the highest cost group for the initial hospitalization, as were 10% of patients with myocardial infarction occurring before discharge.

Government-owned and investor-owned for-profit hospitals were more likely to be in the highest group for average cost than nonprofit hospitals (58% of government owned hospitals and 67% of investor-owned for-profit hospitals vs 27% of nonprofit hospitals, $P = 0.008$) (Table 3). There was an increasing graded relationship between hospital bed size and likelihood of being in the highest group for average cost, with 12% of hospitals with less than 300 beds being in the highest group versus 50% of hospitals with greater than 700 beds ($P = 0.001$). Similarly, 22% of hospitals performing less than 500 surgical procedures per year were in the highest group for average cost, compared to 43% of hospitals performing greater than 10,000 surgical procedures per year. Major teaching affiliation and AMA medical school affiliation were each associated with being in a higher cost group. Of the 7 rural hospitals in the study population, none were in the highest group for average cost.

In general, preoperative comorbidities and greater clinical severity were associated with statistically significant higher risk-adjusted cost ratios. For example, after adjusting for other preoperative factors, patients with fully dependent functional status had 30% higher costs than patients with an independent functional status (cost ratio 1.3, $P < 0.001$) (see Table, Supplemental Digital Content 2, available at http://links.lww.com/SLA/A612, which lists risk-adjusted cost ratios derived from the model). Preoperative ventilator dependence was associated with the highest risk-adjusted cost ratio, with these patients having costs 42% higher than patients without ventilator dependence (cost ratio 1.42, $P < 0.001$). Using benign neoplasm as the reference category, the preoperative diagnoses hemorrhage and inflammatory bowel disease (Crohn disease and ulcerative colitis) were associated with the highest risk-adjusted cost ratios, with cost being 37% higher for patients with hemorrhage and 30% higher for inflammatory bowel disease (cost ratios 1.37 and 1.30, respectively, $P < 0.001$).

Of the postoperative complications occurring before discharge studied, nearly all were associated with higher risk-adjusted cost ratios (see Table, Supplemental Digital Content 2, available at http://links.lww.com/SLA/A612, which lists risk-adjusted cost ratios derived from the model). After adjusting for preoperative risk factors and other complications, patients with respiratory failure had costs 59% higher than patients without respiratory failure (cost ratio 1.59, $P < 0.001$) whereas organ-space SSI was associated with 36% higher costs (cost ratio 1.36, $P < 0.001$). Patients who died before discharge had risk-adjusted costs that were 27% lower than patients who survived to discharge (cost ratio 0.79, $P < 0.001$).

**TABLE 3.** Characteristics of Study Population Hospitals and Associated Percentages of Hospitals That Are in the Lowest, Middle, or Highest Groups for Average Cost to Medicare

| | Total No. Hospitals (%) | Percentage of Hospitals in Lowest Group for Average Cost | Percentage of Hospitals in Mid Group for Average Cost | Percentage of Hospitals in Highest Group for Average Cost | *P* |
|---|---|---|---|---|---|
| Total | 167 | 32.9 | 33.5 | 33.5 | |
| Region | | | | | |
| Midwest | 64 (38.3) | 32.8 | 31.3 | 35.9 | 0.974 |
| Northeast | 46 (27.5) | 34.8 | 37.0 | 28.3 | |
| South | 34 (20.4) | 29.4 | 32.4 | 38.2 | |
| West | 23 (13.8) | 34.8 | 34.8 | 30.4 | |
| Hospital owner | | | | | |
| Government | 24 (14.4) | 20.8 | 20.8 | 58.3 | 0.008 |
| Investor owned; for profit | 9 (5.4) | 11.1 | 22.2 | 66.7 | |
| Nonprofit | 134 (80.2) | 36.6 | 36.6 | 26.9 | |
| Bed size | | | | | |
| <301 beds | 33 (19.8) | 60.6 | 27.3 | 12.1 | 0.001 |
| 301–500 beds | 53 (31.7) | 24.5 | 45.3 | 30.2 | |
| 501–700 beds | 41 (24.6) | 31.7 | 29.3 | 39.0 | |
| >700 beds | 40 (24.0) | 22.5 | 27.5 | 50.0 | |
| Teaching affiliation | | | | | |
| Major teaching | 97 (58.1) | 25.8 | 28.9 | 45.4 | 0.004 |
| Minor teaching | 42 (25.2) | 40.5 | 38.1 | 21.4 | |
| Nonteaching | 28 (16.8) | 46.4 | 42.9 | 10.7 | |
| AMA medical school affiliation | | | | | |
| No | 30 (18.0) | 46.7 | 40.0 | 13.3 | 0.030 |
| Yes | 137 (82.0) | 29.9 | 32.1 | 38.0 | |
| No. inpatient surgical procedures per year | | | | | |
| <5000 | 46 (27.5) | 47.8 | 30.4 | 21.7 | 0.078 |
| 5000–10,000 | 65 (38.9) | 27.7 | 38.5 | 33.9 | |
| >10,000 | 56 (33.5) | 26.8 | 30.4 | 42.9 | |
| Location | | | | | |
| Rural | 7 (4.2) | 71.4 | 28.6 | 0 | 0.055 |
| Urban | 160 (95.8) | 31.3 | 33.8 | 35.0 | |

Structural characteristics of hospitals identified from the American Hospital Association 2013 Hospital Database. Costs were derived from Medicare inpatient claims data as described in the text. Two study population hospitals were excluded from this analysis because of missing data. Mean, standard deviation, and median costs for each group of average costs were as follows: lowest group for average cost: mean $17,858, SD $1300, median $18,162; middle group for average cost: mean $20,886, SD $864, median $20,712; highest group for average cost: mean $26,347, SD $3,578, median $24,969.

When comparing hospital performance for risk-adjusted quality and risk-adjusted cost (using the models that adjust for the procedure performed, ASA class, functional status, indication for surgery, wound class, and whether or not the case was emergent, consistent with the original NQF measure), higher quality was positively correlated with lower average cost (correlation coefficient 0.38, $P < 0.001$) (Fig. 1). A moderate amount of variation was observed in the relationship between quality and cost. Of hospitals in the highest quality group, 52% were in the lowest cost group and 14% were in the highest cost group (Fig. 2). In contrast, 23% of hospitals in the lowest quality group were in the lowest cost group and 41% were in the highest cost group.

There were 29 hospitals identified as highest "value," being in the highest group for quality and the lowest group for cost, and 23 hospitals were identified as lowest "value" (lowest group for quality and highest group for cost). A smaller number of hospitals were identified as high quality, high cost (8 hospitals) or low quality, low cost (13 hospitals). The remaining 96 hospitals were classified as mid quality and/or mid cost. The highest value group included hospitals from all 4 geographic regions (Table 4). Of the nonprofit hospitals in the study population, 19% were designated high value, compared to 8% of government-owned and 11% of investor-owned for-profit hospitals. The percentage of hospitals designated as high value decreased with increasing hospital bed size, with 36% of hospitals with less that

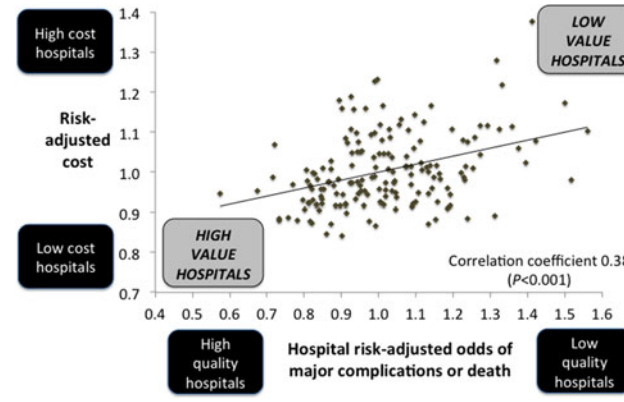


**FIGURE 1.** Correlation between risk-adjusted hospital quality and risk-adjusted cost for colectomy procedures. Each dot represents an ACS-NSQIP hospital (n = 169).

300 beds being high value, compared to 25% of hospitals with 300 to 500 beds, 5% of hospitals with 500 to 700 beds, and 5% of hospitals with more than 700 beds. Similarly, 37% of hospitals performing

fewer than 5000 surgical procedures per year were designated high value, compared to 12% of hospitals performing 5000 to 10,000 and 7% of hospitals performing more than 10,000. Of the nonteaching and minor teaching affiliation hospitals, 32% and 31% were designated high value, compared to 7% of major teaching hospitals. Similarly, 14% of hospitals with an AMA medical school affiliation were high value compared to 33% of the nonaffiliated. Finally, all 7 of the rural hospitals in our study population were designated as high value.

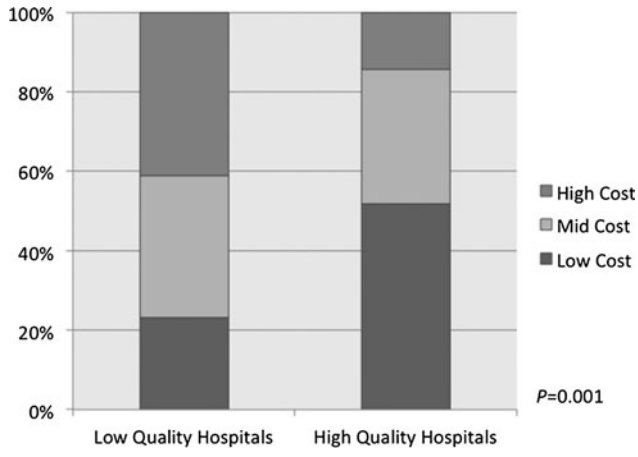


**FIGURE 2.** Association between risk-adjusted hospital quality and risk-adjusted cost for colectomy procedures.

## DISCUSSION

Policymakers are currently focused on improving value in health care by reducing spending while simultaneously improving quality. In this study, we found a statistically significant correlation between higher quality and lower cost for hospitalizations for colectomy procedures. However, we also observed a moderate amount of variation in the relationship between quality and cost, indicating that there is an opportunity for improvement among hospitals of all levels of quality. High-value hospitals, defined as being in the highest group for quality and the lowest group for cost, were located in all 4 geographic regions, included a mix of teaching and nonteaching hospitals, and represented hospitals with a range of bed sizes and numbers of surgical procedures performed annually. We did observe, however, that smaller hospitals and those that did not have a major-teaching affiliation tended to be more likely to be classified as high value.

Currently, measures of surgical quality are reported on Medicare's Hospital Compare Web site, as are general measures of cost

**TABLE 4.** Characteristics of Study Population Hospitals and Associated Percentages of Hospitals That Are Classified as "High Value," "Low Value," "High Cost, High Quality," or "Low Cost, Low Quality"

| | Total No. Hospitals | Percentage of Hospitals Classified as "High Value" | Percentage of Hospitals Classified as "Low Value" | Percentage of Hospitals Classified as "High Cost, High Quality" | Percentage of Hospitals Classified as "Low Cost, Low Quality" |
|---|---|---|---|---|---|
| Total number | 167 | 29 | 23 | 8 | 12 |
| Region | | | | | |
| Midwest | 64 | 20.3 | 9.4 | 3.1 | 6.3 |
| Northeast | 46 | 19.6 | 13.0 | 4.4 | 2.2 |
| South | 34 | 5.9 | 23.5 | 5.9 | 11.8 |
| West | 23 | | | | |
| Hospital owner | | | | | |
| Government | 24 | 8.3 | 20.8 | 8.3 | 4.2 |
| Investor owned; for profit | 9 | 11.1 | 44.4 | 0 | 0 |
| Nonprofit | 134 | 19.4 | 10.5 | 4.5 | 8.2 |
| Bed size | | | | | |
| <301 beds | 33 | 36.4 | 0 | 0 | 3.0 |
| 301–500 beds | 53 | 24.5 | 17.0 | 5.7 | 1.9 |
| 501–700 beds | 41 | 4.9 | 14.6 | 2.4 | 22.0 |
| >700 beds | 40 | 5.0 | 20.0 | 10 | 2.5 |
| Teaching affiliation | | | | | |
| Major teaching | 97 | 7.2 | 16.5 | 8.3 | 9.3 |
| Minor teaching | 42 | 31.0 | 14.3 | 0 | 4.8 |
| Nonteaching | 28 | 32.1 | 3.6 | 0 | 3.6 |
| AMA medical school affiliation | | | | | |
| No | 30 | 33.3 | 6.7 | 0 | 3.3 |
| Yes | 137 | 13.9 | 15.3 | 5.8 | 8.0 |
| No. inpatient surgical procedures per year | | | | | |
| <5000 | 46 | 37.0 | 4.4 | 2.2 | 0 |
| 5000–10,000 | 65 | 12.3 | 21.5 | 3.1 | 12.3 |
| >10,000 | 56 | 7.1 | 12.5 | 8.9 | 7.1 |
| Location | | | | | |
| Rural | 7 | 100 | 0 | 0 | 0 |
| Urban | 160 | 13.8 | 14.4 | 5.0 | 7.5 |

Structural characteristics of hospitals identified from the American Hospital Association 2013 Hospital Database. Costs were derived from Medicare inpatient claims data and risk-adjusted with ACS-NSQIP data, as described in the text. Quality was derived from ACS-NSQIP data, as described in the text. Two study population hospitals were excluded from this analysis because of missing data.

and patient satisfaction with care.[7] Furthermore, the ACA authorized creation of the "value-based payment modifier," which will reward or penalize physicians on the basis of value of the care they provide to Medicare beneficiaries starting in 2017.[3,4] Many have criticized the design of this initiative and of the current publicly reported measures, stating that although the concept and goals are appropriate, the approaches to measuring quality and cost are flawed.[16,17]

How best to define and measure surgical quality has been the subject of much debate and research. Current public reporting and pay-for-performance policies largely focus on structural measures of quality (such as volume of procedures performed or staffing ratios) and process measures of quality (such as the timing of preoperative prophylactic antibiotic administration) because they are relatively easy to assess and typically do not require risk adjustment. However, the validity and importance of these measures as indicators of quality are undermined by their relatively weak link to patient outcomes, suggesting that improved performance on these measures may not result in substantial benefit to patients.[18–23] In this study, we measured hospital quality using an NQF-endorsed risk-adjusted composite measure that reflects hospital performance for serious complications and/or death occurring within 30 days after colectomy procedures. Although we believe that this is a more comprehensive measure of quality than structural or process measures and likely more meaningful and understandable to patients and physicians, it certainly is not perfect. For example, this measure includes the occurrence of 16 serious complications and weights them equally, despite some having arguably more severe consequences than others. This measure also uses clinical, chart-abstracted data, which, while clearly more valid than administrative claims data, can still be burdensome and expensive for hospitals to collect.[8] Further research into the construct and implementation of surgical quality measures is thus warranted.

The current vision of a truly high-value hospital is comprehensive and all-inclusive. A high-value hospital is one in which appropriate care is delivered in an efficient, cost-effective and timely manner, the risk of iatrogenic harm or complications is low, patients recover and achieve improved health, and patients and their families are satisfied with the care they received. Identifying high-value hospitals will thus require integrating measurements across the numerous domains of quality. Although still in the early stages of development, initiatives such as the Choosing Wisely campaign—which aims to address the appropriateness of specific tests and procedures,[24] the Hospital Consumer Assessment of Healthcare Providers and Systems survey—which assesses patient experience and satisfaction,[25] and the Patient Reported Outcomes Measurement Information System—a database of reliable, precise measures of health outcomes from the patient perspective[26] indicate a shift toward a more comprehensive approach to measuring health care quality.

There are 3 distinct entities one can consider when conducting an economic analysis in health care: costs, charges, and payments. Hospital cost for an inpatient hospitalization generally refers to the financial resources consumed by the hospital in providing services for that patient, whereas charges represent the rate billed to the insurer or payer for the hospitalization and are generally higher than costs. Payments represent the amount actually paid to the hospital by the insurer or payer, which is often less than the amount charged. Payment can also be thought of as cost from the perspective of the insurer or payer. Which variable to use thus depends upon the perspective one wants to take for the financial analysis. Costs, arguably, represent the true financial burden incurred by health care as they directly represent the money being spent by hospitals to provide care. However, determining costs of care at the individual patient level is a complex process due to hospital accounting systems that assign resource consumption first to cost centers or departments. Payments for individual patients are much easier to assess. In this study, we took the perspective of the Medicare program for our cost analysis, which may be of greater political interest than cost from the hospital perspective because Medicare funds are derived from nationwide taxpayer participation. Our methodology for defining cost is consistent with that used by the Medicare Spending Per Beneficiary measure, which has been finalized for inclusion in the Hospital Value-Based Purchasing program starting in 2015.[27]

In this study, we found that patients with a postoperative complication occurring before discharge from the primary hospitalization had significantly higher costs than patients without a complication; however, patients with a complication occurring *after* discharge had significantly *lower* costs for the initial hospitalization. Overall, 10% of our study population had a complication occur after discharge, with 7% of patients having only a postdischarge complication. This suggests that assessing the true costs associated with colectomy procedures requires looking at a longer time frame than just the inpatient hospitalization. Furthermore, a recent study reported that 14% of patients undergoing colorectal surgery are discharged to a skilled nursing facility, whereas 20% are discharged with home health care.[28] Additional research is thus needed to identify the contribution of postdischarge care to overall costs attributable to colectomy procedures.

The American College of Surgeons is currently undertaking 3 initiatives aimed at assisting and supporting hospitals interested in improving their value and becoming a highly reliable organization. First, the ACS-NSQIP is embarking on a study that will specifically evaluate successful hospitals within the program to better understand what makes these hospitals positive deviants. Lessons learned from this in depth look will then be shared broadly. Second, a detailed and comprehensive manual entitled Resources for Optimal Quality Surgical Care is currently being written and includes "how to" guides written by health care experts and leaders. Finally, the newly released ACS-NSQIP Quality In-Training Initiative aims to ensure that surgical residency graduates are adequately prepared to design and lead quality improvement initiatives as they transition into surgical practice.[29]

The findings in this study should be interpreted in light of several limitations. First, we attributed the entire cost for a hospitalization to the colectomy procedure despite some patients having a prolonged preoperative or postoperative length of stay, which may not be an appropriate time frame. Second, we used Medicare's perspective for the cost analysis rather than the hospital perspective (ie, cost to Medicare for a hospitalization rather than cost to the hospital). Third, we used a relatively narrow definition of quality as risk-adjusted performance for postoperative major complications and/or death. Finally, ACS-NSQIP hospitals in this dataset are predominantly larger medical centers, which may limit the generalizability of the findings.

## CONCLUSIONS

Policymakers are currently focused on identifying and rewarding high-value health care. Using national ACS-NSQIP and Medicare data, we found an association between higher quality and lower cost surgical care. These results suggest that high-value surgical care is currently being delivered in and can be achieved by a wide spectrum of hospitals and hospital types.

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## DISCUSSANTS

### S. Ashley (Boston, MA):

Porter's value concept is a use construct for thinking about what we ought to be doing to fix health care, but, as this paper shows, it's very difficult to operationalize it practically.

The authors use NSQIP outcomes as a surrogate for quality and Medicare payments as a surrogate for cost to categorize the relative value of hospitals performing colectomy. They found an association between high quality and low cost, and that value could be identified across a spectrum of hospitals.

I have several questions.

The first is whether NSQIP outcomes are really the right measure of quality for a value equation. As was discussed earlier, Porter has argued that morbidity and mortality, what we surgeons are most often concerned about, are only one aspect of this, and that we ought to be focusing on more patient-centered outcomes—such as, pain, patient satisfaction, long-term bowel function, return to work, disease-free survival. Should NSQIP be moving in this direction? Is that what we need to do to really assess?

The cost part of value is even more difficult to assess. Real costs are really a shell game. At academic institutions, we attribute a whole lot of our academic mission into operating room costs, for example. Our actual charges are even more variable. Payments, as in this case with Medicare, may have more to do with what the coders code with the real value of the equation.

Medicare rates are administratively set, the base and operating amounts determined nationally. And once you remove things like geographic and disproportionate share adjustments, as you did, the only variables are the complication and comorbidity adjustments. I was a little surprised that only 8% of patients had such adjustments, so the vast majority of patients just had the standard Medicare payments for colectomy. Value tended to be less in larger, higher volume institutions; teaching hospitals; and those associated with a medical school. Could this just be because these institutions are doing a better job coding for the complications and billing for them?

I'm still not sure I understand the corrections you made for complications in the cost data. As I understand it, by definition, lower quality hospitals had higher complication rates and, if they coded appropriately, would have had higher payments. Is this really a value measurement or is it just a self-fulfilling calculation?

Finally, realizing this study was from 2005 to 2008, I wondered whether you looked at institutions that did more laparoscopic procedures versus open. For us, laparoscopic colectomy is more expensive—mainly OR costs, disposables, and time. It outweighs the slightly shorter length-of-stay and the reductions in narcotics. On the other hand, they have fewer complications, they get back to work sooner, and the cost to the patient and society is less. How do we incorporate those things into a value equation?

### Response From C.Y. Ko:

First, I want to acknowledge Elise's work on this. She has been at this project for 3 years. This is the second time she's presented here at the American, and she loves it.

So, first to answer your 3 questions, the first is the quality components. We all know that quality has several components, outcome being one of them. It's a journey. So, this is where we have started, a lot of us. We all actually have M&Ms ever week, where we start off with the outcome and we go upstream to look at process structure, things upstream to figure out quality. But we mostly start with outcomes. That's what we started with in this study. Clearly, we need to go further. We need other components of quality, the ones that you mentioned, patient experience, patient-reported outcomes. Appropriateness is a huge thing.

When we have started to dabble into this on this project, we put in the cap scores for these places. We found largely, and others have published this as well, that the component of caps, patient experience, and outcomes don't correlate very well. Subsequently, that doesn't correlate very well with the cost numbers. But that's probably a good thing because if they all correlated, we only need to measure one thing, because that will be a proxy for quality overall.

What we are finding is that there's multiple components. They don't all track together, which is good for us because we need to have multiple components of quality.

The second piece is the economic piece. How do we measure the economic piece? I'm sure all of you have tried to look at the economic piece within your hospitals, and that's a good term. It's totally a shell game.

When we have the Medicare data, there are 3 types of economic data: the cost, the charges, and the payments. And in theory, there are a lot of theoretical issues with each of those, and there are theoretical reasons, pros and cons, for each of those 3. When we did this same analysis with each of those 3, we get largely the same answer. For a given case, it might be more one or the other, but overall they give us the same answer, which is the association that you saw.

Your last question was the lap. In general, the higher value places seem to be doing more lap. And right now we are drilling deeper in this work and looking at the cost centers, because Medicare gives us approximately 38 different cost centers, 12 or so of which are appropriate for surgery. As we look at that, the 2 biggest drivers, as I'm sure everyone in the room knows, are the length of stay and the time in the operating room. So, lap might take longer time in the OR, so that is going to cost more, but there's a decreased length of stay. And as you look at the literature, some people say it costs more, some people say it costs less, and it's going to be the convenience sample of that study as to which one trumps which one, OR time versus length of stay.

What we have found is that overall for these 100-plus hospitals is that, again, the hospitals that have high value tend to do more lap. And we are finding that within our hospitals right now, within NSQIP, that if we go through and find the cases that have zero complications, so they fly through, which will be about 75% of the colon cases, as an example, the laps tend to do better overall in terms of when we look at those 2 constructs, OR time and length of stay.

## DISCUSSANTS

### C.M. Schmidt (Indianapolis, IN):

These data present significant challenges but also significant opportunities to take better care of patients going forward.

One thing that concerned me is the possibility that procedural volume could be a confounding factor. As espoused by Birkmeyer and others, greater volumes of a particular procedure often seen in larger hospitals tend to beget better outcomes. Your data do not necessarily support this. I know there were likely certain assumptions made on the basis of the size of the institution. But in terms of volumes for a particular procedure, I'm concerned that if you didn't account for volume specifically that it may be confounding variable. For example, if you were the "one hit wonder" and did a single procedure really well, were in a group with low cost (ie, low volume, low cost), and had no procedure-related complications, this could obviously skew the data one way. Conversely, if you did a single procedure and did poorly, it could skew the data the other way. On the basis of this, I am curious as to how you might have accounted for volume as a potential confounding factor.

### Response From C.Y. Ko:

I won't get into the deep statistics of it, but we do do reliability adjustments and hierarchical modeling to adjust for this issue of sample size, which is an issue for all analyses that anyone does. If you have lower sample sizes, it's less reliable and there's a lot more noise and jumping of the data. This is reliability adjusted as well as risk adjusted to take into account for that.

I think you raised a really good point in terms of volume centers, and what we think we are seeing is that the high-volume centers can be, but don't have to be, the things that Dr Hoyt talked about yesterday, the highly reliable organizations (HROs). The high-volume centers that are HROs, that have more standardization, probably better culture, are using data to measure how they are doing and working on improving; those are the ones that are giving efficient care and also standardizing and having less complications.

Those are the ones that we see just anecdotally as we visit our trauma hospitals, our cancer hospitals. Those are the hospitals that are doing really well. But high volume doesn't have to do that. As you can see, 10% to 20% of hospitals provide high quality, but still have high cost. Those hospitals might have high volume but are not highly reliable organizations.

I don't know what measure we can use to be the proxy for HRO, but anecdotally, as we visit the 400 or 500 trauma hospitals on those visits, or the 1500 cancer hospitals on those visits, that's what we anecdotally see. That's what brought about Dr Hoyt's idea to have this quality manual. A lot of authors are in this audience as I look around. How do we identify those aspects that will allow us to be that HRO in a group of surgeons, in a surgery department or a group of surgeons in a practice or what-not. That's really what we are trying to get at with that high quality about which you are asking.

## DISCUSSANTS

### T. Sundt (Boston, MA):

I apologize for my naïveté about statistical methodology. Is it possible to do a sensitivity analysis in some way to look at the impact of the accuracy of your assessment of cost on your results?

At one of my former institutions that I think has pretty good true cost data, meaning cost to the hospital, the delta between the cost to the hospital and the cost to Medicare was 20%, in cardiac surgery. So, it can be a pretty big number. If you are off by that much, what does that do to your conclusions?

### Response From C.Y. Ko:

In the back rooms of doing this project, we just took people in the room. So, I met with Bruce Hall and especially Mike Henderson at the Cleveland Clinic. He was very open to looking at his books and his other data, as is Bruce Hall, who runs his 13-hospital system for the quality of that. And it was basically what Stan said. It was a shell game. We couldn't get deep enough in the data that we wanted to get at what you are talking about to make a very good assessment of that. It's still too difficult or we haven't found out the way to do that. You see one, you see one. We couldn't find any way to do this logically across the board.

## DISCUSSANTS

### D. Rothenberger (Minneapolis, MN):

No disclosures.

Just as you mentioned about the highly reliable organization (HRO), I wonder about the implications regarding teaching hospitals, which you alluded to. Could you expand on that just a little bit?

### Response From C.Y. Ko:

Earlier in this meeting and in other meetings, there are always discussions that academic medical centers are less efficient, that they have more complications, maybe they rescue better because there are folks around, so they have maybe a higher complication rate and a lower mortality rate. At least that's what the data show. I think that somebody used NSQIP data, as well as other data, to show that as well.

This question is larger than the one we considered in this study, obviously. This study was to show that although in general that's what happens, large academic medical centers tend to be less efficient, have more complications, and provide lower value. There are academic medical centers that are able to be high value and produce good quality at lower cost. If you haven't read this book, read *The Power of Positive Deviation*: it looks across-the-board at the 5% of deviants who positively have figured out the way. That's probably what we need to do for the academic medical centers, identify the high value, the academic medical centers that are producing the high value and look at that. Again, I think it is that concept of the HRO.

## DISCUSSANTS

### G. Kennedy (Madison, WI):

I'm not sure I know the answer to your question: is high-quality, low-cost surgical care achievable everywhere at the end of your paper? I guess there are 2 ways we could take the work. One way would be, as Dr Monson suggested yesterday, to support the creation of centers of excellence. The other is to go out and tell everyone to "Be better."

What's your sense? Where do you stand on this concept of centers of excellence versus supporting the colorectal surgeon leaders in the country, trying to go out and spread the word to the smaller centers and say, "Hey, just do better."

### Response From C.Y. Ko:

I think there are theoretical and realistic responses to that question. In theory, it would be great if we could have regionalization and send everyone to some center of excellence. I don't think, at least so far, with the way our payment system and our health care system works, it would be a great theoretical discussion. It's probably not going to happen to the extent that it happens in Europe and maybe in Canada.

Can everyone become better, more reliable, more standardized, look at their data, and do that? Yes. And so that's another message of this that we see. There are high-volume hospitals, low-volume hospitals, rural, urban, teaching, nonteaching that have achieved high value. I would hope that that can be achieved everywhere.