Title

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Journal
Journal of the American College of Surgeons, 220(3)

ISSN
1072-7515

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Publication Date
2015-03-01

DOI
10.1016/j.jamcollsurg.2014.11.011

Peer reviewed

Is There Hospital Variation in Long-Term Incisional Hernia Repair after Abdominal Surgery?

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BACKGROUND: Currently, hospital benchmarking organizations are often limited to short-term surgical quality comparisons among hospitals. The goal of this study was to determine whether long-term rates of incisional hernia repair after common abdominal operations could be used to compare hospital long-term surgical quality.

STUDY DESIGN: This was a cohort study with up to 4 years of follow-up. Patients who underwent 1 of 5 common inpatient abdominal operations were identified in 2005−2008 American College of Surgeons NSQIP data linked to Medicare inpatient records. The main outcomes included occurrence of an incisional hernia repair. A multivariable, shared frailty Cox proportional hazards regression was used to compare each hospital's incisional hernia rate with the overall mean rate for all hospitals and control for American College of Surgeons NSQIP preoperative clinical variables.

RESULTS: A total of 37,134 patients underwent 1 of 5 common inpatient abdominal operations, including colectomy, small bowel resection, ventral hernia repair, pancreatic resection, or cholecystectomy, at 1 of 216 hospitals participating in American College of Surgeons NSQIP during the 4-year period. There were 1,474 (4.0%) patients who underwent an incisional hernia repair, at a median follow-up time of 16 months (interquartile range 8 to 25 months) after initial abdominal surgery. After risk adjustment, there was no significant difference in the ratio of any one hospital's adjusted hazard rate for incisional hernia repair vs the average hospital adjusted hazard rate.

CONCLUSIONS: Risk-adjusted hospital rates of incisional hernia repair do not vary significantly from the average. This suggests that incisional hernia repair might not be sensitive enough as a long-term quality metric for benchmarking hospital performance. (J Am Coll Surg 2015; 220:313−322. © 2015 by the American College of Surgeons)

Current benchmarking efforts for hospital surgical performance focus on short-term, often 30-day, outcomes like surgical site infection, partly due to the costs of long-term clinical data collection. However, certain postoperative complications only manifest in the long term, such as the development of an incisional hernia requiring surgical repair. This presents a challenge for benchmarking organizations, such as the American

CME questions for this article available at http://jacscme.facs.org

Disclosure Information: Authors have nothing to disclose. Timothy J Eberlein, Editor-in-Chief, has nothing to disclose.

Support: Supported by the Robert Wood Johnson Foundation Clinical Scholars Program and the US Department of Veterans Affairs (grant no. 70039). Drs Hall and Ko are paid consultants for the American College of Surgeons.

Abstract presented at the Academic Surgical Congress, San Diego CA, February 2014.

Received June 22, 2014; Revised November 9, 2014; Accepted November 12, 2014.

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http://dx.doi.org/10.1016/j.jamcollsurg.2014.11.011
ISSN 1072-7515/14

College of Surgeons (ACS) NSQIP, which collect clinical data to risk-adjust hospital performance, but for the sake of parsimony and cost, limit follow-up to 30 days postoperatively.[1,2]

Limited long-term follow-up data could be improved by linking clinical data with longer-term administrative data.[3,4] Such linked datasets can capitalize on the strength of each data source. Clinical datasets contain high-quality preoperative patient clinical variables necessary for rigorous risk adjustment of postoperative outcomes,[5-9] and administrative datasets contain long-term follow-up of beneficiary health care encounters.[10] The resulting linked dataset might offer the best of both worlds in terms of risk adjustment and long-term follow-up. A well-known example of such a linked dataset is SEER-Medicare.[11,12]

Useful metrics for long-term performance benchmarking should ideally meet 3 criteria. They should be clinically relevant, be reliably and frequently captured in administrative data, and have sufficient variation attributable to surgical care after controlling for patient preoperative clinical characteristics. Complication diagnoses and readmissions have been used to compare benchmark hospital performance, but have limitations. Postoperative complication diagnoses are not well captured by administrative data.[6,13,14] Readmissions are influenced by many factors unrelated to operative care.[15,16]

In contrast, procedures performed in the operating room are captured reliably in administrative data.[17,18] One potential metric could be incisional hernia repair, which is the definitive treatment for patients with a symptomatic incisional hernia after abdominal surgery. Incisional hernias are clinically relevant long-term outcomes that typically present after 30 days and up to 10 years postoperatively.[19-23] However, it is unclear whether there is enough variation in incisional hernia repair rates among hospitals to detect differences in surgical quality of care. Ideally, differences between each hospital and the average hospital performance could be detected after controlling for patient preoperative clinical characteristics.

The overarching goal of this study was to determine the feasibility of comparing hospitals' performance as defined by the long-term incisional hernia repair rate after abdominal surgery using a linked clinical−administrative dataset. The specific aims were 2-fold: to determine whether incisional hernia repair is frequently captured in linked clinical−administrative dataset, and varies significantly among hospitals after controlling for important ACS NSQIP patient preoperative clinical characteristics.

METHODS

Data source and inclusion criteria

This is an observational study where two datasets, the ACS NSQIP and the Medicare inpatient records file (Medicare Provider Analysis and Review file) from 2005 to 2008, were linked. This was accomplished by using indirect patient identifiers and a deterministic linkage algorithm to identify Medicare recipients undergoing inpatient operations at ACS NSQIP−participating hospitals.[3] The ACS NSQIP is a surgical clinical registry that prospectively collects preoperative clinical data and 30-day postoperative outcomes with dedicated trained clinical abstractors at participating hospitals.[2,8] The Medicare inpatient records file is an administrative dataset containing demographic data, diagnoses (up to 10), and procedures (up to 6) billed to Medicare for all inpatient Medicare beneficiary encounters. By nature of this linked dataset, this study included only patients 65 years and older and Medicare fee-for-service patients. The linked dataset created an opportunity to capitalize on the strengths of each dataset. The ACS NSQIP provided detailed patient preoperative clinical data and Medicare inpatient records captured all procedure codes and associated dates at all hospitals where the beneficiary sought inpatient care between 2005 until the end of 2008. This allowed for the identification of not only whether a reoperation for incisional hernia occurred, but when it occurred.

The 5 most common abdominal operations (ie, colectomy, cholecystectomy, small bowel resection, ventral hernia repair, and pancreatectomy) were identified in the ACS NSQIP primary procedure data field using CPT codes (Appendix 1; available at: http://www.journalacs.org). Only patients who underwent 1 of these 5 operations during 2005 to 2008 at an ACS NSQIP participating hospital were included. A flow diagram was created to demonstrate how the final cohort was identified (Appendix 2; available at: http://www.journalacs.org).

Demographics (eg, age), preoperative clinical variables (eg, type of surgery, comorbidities), and postoperative 30-day complications data in ACS NSQIP were identified for patients who underwent 1 of the 5 index abdominal operations. Postoperative complications assessed included mortality, surgical site infection, wound dehiscence, unexpected return to the operating room, and composite morbidity (defined as occurrence of any of the following complications: surgical site infection [composite of superficial, deep, and organ space], wound disruption, sepsis, pneumonia, reintubation, failure to wean, intra-/postoperative transfusion, cardiac arrest, MI, deep vein thrombosis, pulmonary embolism, coma, stroke, peripheral nerve injury, renal failure, and urinary tract infection).

Primary outcomes

The primary outcomes measure was whether or not an incisional hernia repair was billed for each patient during the length of the study period in the Medicare inpatient records. An incisional hernia repair was defined as present if an ICD-9 procedure code for incisional hernia repair was identified in any of the 6 procedure data fields in the Medicare inpatient records (Appendix 3; available at: http://www.journalacs.org) and occurred at least 2 days after the index operation date, either during the hospitalization or during subsequent hospitalizations. This was done to avoid counting the index abdominal operation (or concurrent repairs of existing ventral hernias) as a reoperation. The presence of a new postoperative incisional hernia ICD-9 diagnosis code in any of the 10 diagnosis data fields in the Medicare inpatient records was recorded to determine concordance of the postoperative incisional hernia repair with the diagnosis of postoperative incisional hernia as a sensitivity check.[5,6,14]

The time to occurrence of the outcomes was calculated by taking the difference between ACS NSQIP index surgery date and incisional hernia repair date in the Medicare inpatient records. The patients who did not undergo postoperative incisional hernia repair had a follow-up time variable equal to the number of days that the patients were effectively "followed" in the Medicare inpatient records after index surgery. This was calculated by taking the difference of the last date of possible postoperative procedure capture in the Medicare inpatient records, December 31, 2008, and the ACS NSQIP index surgery date. Patients who were alive and did not have an incisional hernia repair billed during the follow-up time period (n = 18,575) and patients who died (n = 9,924) without having an incisional hernia repair, were treated as censored observations in the subsequent survival analysis.

Statistical analyses

Continuous preoperative variables, such as age and BMI, were made categorical. Age was divided into the following categories; 65 years to younger than 75 years of age, 75 years to younger than 85 years of age, and 85 years of age and older. Body mass index was divided into the following categories: <18.5 kg/m^2, 18.5 to <25 kg/m^2, 25 to <30 kg/m^2, 30 to <35 kg/m^2, 35 to <40 kg/m^2, ≥ 40 kg/m^2. The frequencies of preoperative ACS NSQIP demographic and clinical variables were compared between patients who had incisional hernia repairs and those who did not using chi-square tests.

The preoperative demographic and clinical variables before the index abdominal operations associated with the rate of incisional hernia repair were identified using univariate Cox proportional hazards models. A multivariable, mixed effects Cox proportional hazards model, also known as a frailty model, was constructed based on the preoperative clinical variables found to be significantly different on univariate analysis, as defined by p value <0.05. Additionally, a procedural CPT linear risk variable commonly used in current ACS NSQIP risk-adjustment methodology[23] was included in the multivariable model as a necessary adjustment for the influence of procedural case mix on the risk of incisional hernia repair. This CPT linear risk variable was used for procedural case-mix adjustment instead of procedure-specific categories to save degrees of freedom in the risk-adjustment model and obtain more precise estimates of risk associated with each of the 25 CPT codes in the analysis. The CPT linear risk values corresponding to a CPT code were defined as the logit of the probability of incisional hernia associated with that CPT code. Logits were predicted via logistic regression models adjusted for relevant covariates, such as age and American Society of Anesthesiologists (ASA) class.

The mixed effects Cox proportional hazards model can be referred to as a shared frailty model because the addition of the random intercepts accounts for "shared frailty," or a propensity to experience the event shared by members of a cluster, but heterogeneous across clusters (the hospitals in this study). Patients were assigned to the ACS NSQIP institution where the index operation was performed for the purposes of clustering and the incisional hernia development was attributed to that ACS NSQIP institution regardless of where the postoperative incisional hernia repair was performed. Frailty models were initially pioneered as a way of accounting for unobserved individual variation in propensity for certain outcomes across time.[24,25] More recently, shared frailty models have been used to account for clustering of observations within a group of individuals.[26] The multivariable mixed effects Cox proportional hazard model was used to risk adjust, control for clustering at the hospital level, and account for censoring (Eq. 1). The fixed effects were the procedural case-mix adjustment in the form of the procedural CPT linear risk variable, and the ACS NSQIP preoperative clinical variables. The random effects were the ACS NSQIP hospital where the index major abdominal operation was performed. This model was subsequently used to quantify hospital variation in incisional hernia repair by calculating each hospital's frailty estimates or the exponentiated best linear unbiased predictor of the hospital (random) intercept and respective 95% CI. The frailty estimate for a hospital is interpreted as the ratio of that hospital's hazard rate of incisional hernia repair over the average hospital's hazard rate with equivalent patient characteristics and procedural case mix. The 95% CIs were plotted on the point frailty estimates sorted in ascending order. If both

Table 1. Clinical Differences in Patients Who Underwent Incisional Hernia Repair after Index Common Abdominal Operation

	Incisional hernia repair (n = 1,474)		No incisional hernia repair (n = 35,660)		
Clinical variables	**n**	**%**	**n**	**%**	**p Value***
Demographics					
Male	696	47.2	15,834	44.8	0.04
Age category, y					<0.001
65 to <75	807	54.8	16,372	45.9	
75 to <85	553	37.5	14,536	40.8	
≥85	114	7.7	4,752	13.3	
Surgery specific variables					
Procedure					<0.001
Colectomy					
Open colectomy	580	39.4	13,352	37.4	
Laparoscopic colectomy	130	8.8	4,457	12.5	
Cholecystectomy					
Open cholecystectomy	47	3.2	2,255	6.3	
Laparoscopic cholecystectomy	67	4.6	4,746	13.3	
Ventral hernia repair	247	16.8	3,483	9.8	
Small bowel resection	309	21.0	4,833	13.6	
Pancreatic resection	94	6.4	2,534	7.1	
Emergency case status	345	23.4	6,326	17.7	<0.001
Cardiovascular conditions					
MI	19	1.3	457	1.3	0.48
Congestive heart failure	31	2.1	879	2.5	0.68
Metabolic and endocrine conditions					
10% weight loss	71	4.8	2,153	6.0	0.31
Diabetes					0.92
No diabetes	1,182	80.2	28,495	79.9	
Diabetes on oral hypoglycemic	194	13.2	4,779	13.4	
Insulin dependent diabetes	98	6.7	2,386	6.7	
BMI, kg/m^2					<0.001
<18.5	69	4.7	2,356	6.6	
18.5 to <25	336	22.8	11,523	32.3	
25 to <30	532	36.1	11,980	33.6	
30 to <35	293	19.9	6,064	17.0	
35 to <40	144	9.8	2,353	6.6	
≥40	100	6.8	1,384	3.9	
Pulmonary conditions					
Smoker	183	12.4	3,619	10.2	0.003
COPD	180	12.2	3,549	10.0	<0.001
Ventilator dependence	43	2.9	619	1.7	<0.001
Renal conditions					
Dialysis	8	0.5	278	0.8	0.75
Acute renal failure	26	1.8	414	1.2	0.001
Hepatic conditions					
Varices	7	0.5	52	0.2	0.05
Ascites	52	3.5	1,041	2.9	0.18

(Continued)

Table 1. Continued

Clinical variables	Incisional hernia repair (n = 1,474) n	%	No incisional hernia repair (n = 35,660) n	%	p Value*
Hematologic and immunologic conditions					
Bleeding disorder	149	10.1	3,386	9.5	0.43
Steroid use	105	7.1	1,613	4.5	<0.001
Cancer	45	3.1	1,362	3.8	0.13
Chemotherapy	29	2.0	533	1.5	0.15
Radiotherapy	26	1.8	474	1.3	0.16
Acuity of illness					
Open wound	87	5.9	1,157	3.2	<0.001
Any surgery in previous 30 days	70	4.8	981	2.8	<0.001
Functional status					<0.001
Not limited	1,233	83.7	30,397	85.3	
Partially limited	161	10.9	3,785	10.6	
Fully limited	80	5.4	1,478	4.1	
ASA class					<0.001
I	7	0.5	301	0.8	
II	372	25.2	10,744	30.1	
III	873	59.2	20,151	56.5	
IV	211	14.3	4,216	11.8	
V	11	0.8	248	0.8	
Preoperative sepsis					<0.001
No sepsis	1,182	80.2	30,107	84.4	
Systemic inflammatory response syndrome	191	13.0	3,698	10.4	
Sepsis	41	2.8	936	2.6	
Septic shock	60	4.1	919	2.6	

*p Value generated from chi-square test of unadjusted frequencies of preoperative categorical variables.
ASA, American Society of Anesthesiologists.

confidence limits were >1, then the hospital had a statistically significant higher rate of incisional hernia repair compared with the average hospital. If both confidence limits were <1, then the hospital had a statistically significant lower rate compared with the average hospital. It should be reinforced that frailty estimates quantify how hospitals performed with respect to the average hospital, not with respect to one another.

$$\lambda_{i(j)}(t) = \lambda_0(t)\omega_j e^{Xi\beta} \quad \text{(Eq 1)}$$

where $\lambda_{i(j)}(t)$ is the hazard function for patient i in hospital j, $\lambda_0(t)$ is the baseline hazard function, ω_j is the frailty for hospital j, X^i is the covariate vector for patient i, and β is the vector of regression coefficients.

Lastly, hospitals were ranked into deciles based on their frailty estimates and therefore the mean risk-adjusted incisional hernia repair rate. The 30-day complications were compared between the hospitals with the highest risk-adjusted incisional hernia repair rate (10% of hospitals with the highest risk-adjusted incisional hernia repair rate or the highest decile) and the hospitals with the lowest risk-adjusted incisional hernia repair rate (10% of hospitals with the lowest risk-adjusted incisional hernia repair rate or the lowest decile) using a multivariable logistic regression. The variables included in the model were sex, age, procedural CPT linear risk, emergency case, diabetes, BMI, smoker, renal failure, ascites, steroid use, chemotherapy, open wound, any surgery in the previous 30 days, ASA class, and preoperative sepsis.

RESULTS

A total of 37,134 patients were identified to have undergone 1 of the 5 index general surgery operations at 1 of 216 hospitals participating in ACS NSQIP during the 4-year period. The median follow-up time was 16 months with an interquartile range of 8 to 25 months.

Table 2. Frailty Model for Incisional Hernia Repair

Clinical variables	Hazard ratio*	95% CI*	p Value*
Demographics			
Male	1.11	1.00–1.24	0.04†
Age category, y			
65 to <75 (reference)	(1.00)		
75 to <85	0.86	0.77–0.96	0.01†
≥85	0.63	0.52–0.78	<0.001†
Surgery-specific variables			
Procedural CPT linear risk	2.32	2.04–2.62	<0.001†
Emergency case status	1.14	0.98–1.33	0.10
Metabolic and endocrine conditions			
Diabetes			
No diabetes (reference)	(1.00)		
Diabetes on oral hypoglycemic	0.86	0.74–1.00	0.05
Insulin dependent diabetes	0.76	0.61–0.94	0.01†
BMI, kg/m^2			
<18.5	0.90	0.69–1.17	0.42
18.5 to <25 (reference)	(1.00)		
25 to <30	1.48	1.29–1.70	<0.001†
30 to <35	1.61	1.37–1.89	<0.001†
35 to <40	2.02	1.65–2.47	<0.001†
≥40	2.31	1.83–2.92	<0.001†
Pulmonary conditions			
Smoker	1.14	0.97–1.33	0.12
Renal conditions			
Acute renal failure	1.27	0.83–1.92	0.27
Hepatic conditions			
Ascites	1.08	0.81–1.43	0.62
Hematologic and immunologic conditions			
Steroid use	1.40	1.14–1.71	<0.001†
Chemotherapy	1.12	0.77–1.63	0.54
Acuity of illness			
Open wound	1.63	1.30–2.05	<0.001†
Any surgery in previous 30 days	1.29	1.00–1.66	0.05
ASA class			
I (reference)	(1.00)		
II	1.56	0.69–3.49	0.28
III	1.87	0.84–4.18	0.13
IV	2.11	0.93–4.78	0.07
V	2.02	0.73–5.57	0.18
Preoperative sepsis			
No sepsis (reference)	(1.00)		
Systemic inflammatory response syndrome	1.11	0.93–1.32	0.26
Sepsis	0.85	0.61–1.18	0.33
Septic shock	1.22	0.88	0.23

*p Values, hazard ratios and 95% confidence intervals generated from the mixed effects multivariable Cox proportional hazards model. All variables included in the model as listed.
†Significant results.
ASA, American Society of Anesthesiologists.

During the entire follow-up period 1,474 patients (4.0%) underwent incisional hernia repair. For the entire cohort, 200 (0.5%) patients were diagnosed with a postoperative incisional hernia. A total of 176 of these 200 patients (88.0%) diagnosed with a postoperative incisional hernia also had an incisional hernia repair.

There were small differences in preoperative variables pertinent to the index operation between patients who later required incisional hernia repair and those who did not (Table 1). Patients who required a subsequent incisional hernia repair more frequently had an emergent index abdominal operation (22.9% vs 17.7%; $p < 0.001$), smoked (12.4% vs 10.2%; $p = 0.003$), or used steroids within 30 days preoperatively (7.1% vs 4.5%; $p < 0.001$). Additionally, a larger proportion of patients who required a subsequent incisional hernia repair after abdominal surgery had a BMI $\geq$40 kg/m^2 (6.8 vs 3.9%; $p < 0.001$). These differences were statistically significant but are of unclear clinical significance.

The frailty model demonstrated that multiple patient preoperative clinical variables from the index abdominal operation were associated with the incisional hernia repair rate (Table 2). The CPT linear risk of the index operation (hazard ratio = 2.32; 95% CI, 2.04−2.62) was highly associated with the incisional hernia repair rate. A BMI between 35 and 40 kg/m^2 was associated with a 2.02 increase in the hazard rate of incisional hernia repair (hazard ratio = 2.02; 95% CI, 1.65−2.27) compared with BMI 18.5 to 25 kg/m^2. Similarly, a BMI $\geq$40 kg/m^2 was associated with a 2.31 increase in the hazard rate of incisional hernia repair (hazard ratio = 2.31; 95% CI, 1.83−2.92) compared with BMI 18.5 to 25 kg/m^2.

The same model was used to calculate how the incisional hernia repair rate varied across the ACS NSQIP participating hospitals. After accounting for all preoperative clinical variables depicted in Table 2, there was very slight variation in risk-adjusted long-term incisional hernia repair rates, or frailty estimates, across hospitals (Fig. 1). None of the individual hospitals were significantly different from the average hospital with equivalent patient and procedural characteristics (denoted at 1 on y-axis). This is depicted by the fact that the error bars denoting the CIs of all hospitals' frailty estimates overlapped one in Figure 1. In the lowest-decile hospitals, 2.3% of patients had an incisional hernia repair compared with 6.6% in the highest-decile hospitals.

Thirty-day outcomes were compared between the lowest- and highest-decile hospitals and in relation to all the intermediate deciles (Table 3). The lowest-decile hospitals had lower 30-day morbidity after the index procedure (23.1 vs 28.0%; adjusted odds ratio = 0.74; 95% CI, 0.67−0.83; $p < 0.001$) and 30-day return to the operating room (5.2 vs 7.8%, adjusted odds ratio = 0.65; 95% CI, 0.54−0.78; $p < 0.001$) compared with highest decile hospitals.

A sensitivity analysis was done eliminating patients who had surgery in the previous 30 days or who had had a previous ventral hernia repair. This sensitivity analysis included 35,154. There was no difference in the variables associated with incisional hernia repair rate. No more hospitals were designated as statistically significantly different from the average hospitals as compared with the study with the full cohort of 37,134.

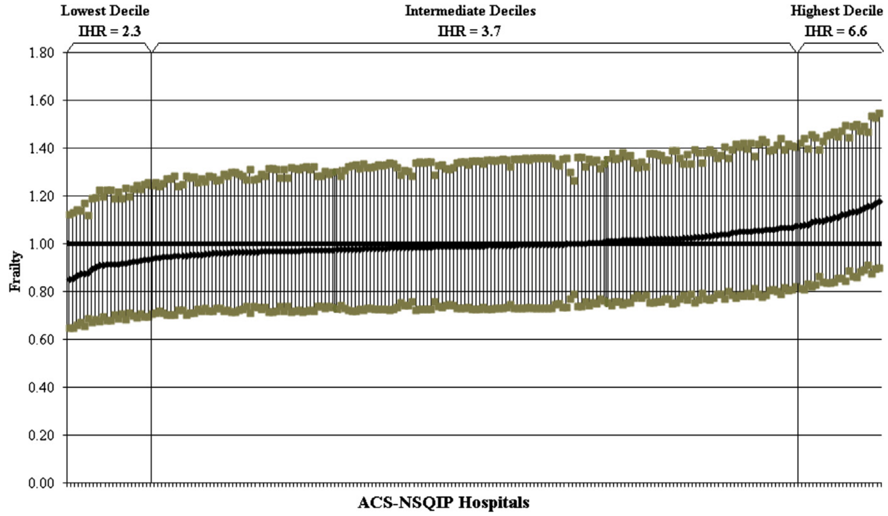

Figure 1. Long-term risk-adjusted incisional hernia repair rates by hospital after 5 common major abdominal operations. Risk-adjusted hospital frailty and 95% CIs of 216 American College of Surgeons (ACS) NSQIP hospitals. IHR, incisional hernia repair.

Table 3. Postoperative Complication Rates after Index Surgery in Lowest- and Highest-Decile Hospitals

30-Day postoperative complication	Lowest decile (n = 21), %	Highest decile (n = 21), %	Adjusted odds ratio*	Adjusted 95% CI*	p Value*
Composite morbidity	23.1	28.0	0.74	0.67−0.83	<0.001
Surgical site infection	9.7	12.2	0.79	0.68−0.91	0.003
Dehiscence	1.3	2.1	0.61	0.43−0.86	0.002
Sepsis	4.3	6.3	0.66	0.56−0.78	<0.001
Return to operating room	5.2	7.8	0.65	0.54−0.78	<0.001
Mortality	4.6	4.7	0.85	0.67−1.07	0.22

*Adjusted odds ratio, 95% CI, and p value generated from multivariable logistic regression comparison of 30-day postoperative complications in 10% of hospitals with the lowest adjusted incisional hernia repair rate compared with 10% of hospitals with the highest adjusted incisional hernia repair rate (deciles by hospital adjusted incisional hernia repair rate) controlling for sex, age, procedure case mix, emergency case, diabetes, BMI, smoker, renal failure, ascites, steroid use, chemotherapy, open wound, any surgery in the previous 30 days, American Society of Anesthesiologists class, and preoperative sepsis.

DISCUSSION

Certain markers of surgical quality, such as incisional hernia, might not manifest until several months postoperatively.[27-30] Benchmarking hospital long-term performance has been difficult due to the limited follow-up of most clinical datasets.[5,6,8] This study sought to benchmark long-term performance and found no statistically significant distinctions (at the 5% level) of any one hospital's long-term performance from the average hospital using incisional hernia repair as the primary outcomes metric. However, hospitals with the highest risk-adjusted incisional hernia repair rates did have slightly higher rates of some 30-day complications compared with the hospitals with the lowest incisional hernia repair rates. There is face validity to this finding, as 30-day postoperative complications could be seen as intermediate outcomes that could predispose to ultimate incisional breakdown. Other authors using linked datasets have described similar findings between short/intermediate outcomes and long-term outcomes.[4,31] However, the differences observed in this study might not be of a clinically significant magnitude.

It appears that long-term inpatient incisional hernia repair is not sensitive enough as a quality metric to discriminate how well hospitals perform compared with the average hospital, at least within our current model construct. However, it is difficult to know with certainty whether this finding should be attributed to a flawed construct (such as inadequate risk adjustment), insensitive detection of the true outcome (hernia); the proxy (inpatient repair procedure code), which itself could represent a flawed proxy (repair might not always be undertaken, or not as inpatient); or whether the long-term outcome is not adequately influenced by surgeons and hospitals to reflect differences in long-term quality. Although few incisional hernia diagnoses were found in the absence of the repair procedure code, the incisional hernia repair rate in this study was at the lower limit of the known incidence range of incisional hernia (4% to 20%) after abdominal surgery, indicating the proxy itself (billed code for repair) could be an underestimate.[29,32-34] The proxy might be an underestimate due to inattentive coding practices, but because the code represents a billable procedure, coding deficiency is unlikely. The proxy could be an underestimate if repairs were not always undertaken, but again, only 12% of patients with the coded hernia diagnosis did not have a subsequent procedure code for incisional hernia repair. More likely, underestimation results from an absence of outpatient procedure codes in the Medicare inpatient records. Earlier studies of NSQIP as well as the Healthcare Cost and Utilization Project and the National Survey of Ambulatory Surgery have found that 40% to 85% of abdominal wall hernias were performed in the inpatient setting.[35-37]

This study has other important limitations. The Medicare inpatient records file does not capture encounters for patients who subsequently switched to a Medicare managed-care plan. Although this is a minority of patients in this study, managed-care enrollment did increase nationally during the 4 years of this study; 3% in 2005, 12% in 2006, 21% in 2007, and 32% in 2008. No enrollment file was obtained from Medicare, therefore, patients who were discontinuously enrolled in Medicare fee-for-service could not be excluded. This could also have contributed to underestimating long-term repair rates, although it is not obvious how it could be a source of bias across hospital comparison. A second limitation is that Medicare claims can be submitted up to 1 year after service delivery. This might have led to a censoring of certain observations. Finally, the findings of this patient sample of Medicare beneficiaries within ACS NSQIP hospitals might not be generalizable to younger populations or non−ACS NSQIP hospitals.

CONCLUSIONS

This study demonstrates that there is insufficient variation in long-term incisional hernia repair rate to differentiate any hospital from the average hospital under the construct proposed. Although hospitals with the highest risk-adjusted rates of long-term incisional hernia repairs had somewhat higher rates of 30-day complications, the magnitudes of those differences were of uncertain clinical significance. Additional studies are needed to identify a useful long-term quality benchmarking metric in this clinical area.

Author Contributions

Study conception and design: Stey, Ko
Acquisition of data: Lawson, Zingmond
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Drafting of manuscript: Stey, Russell, Hall, Lin, Gibbons, Lawson, Zingmond, Ko
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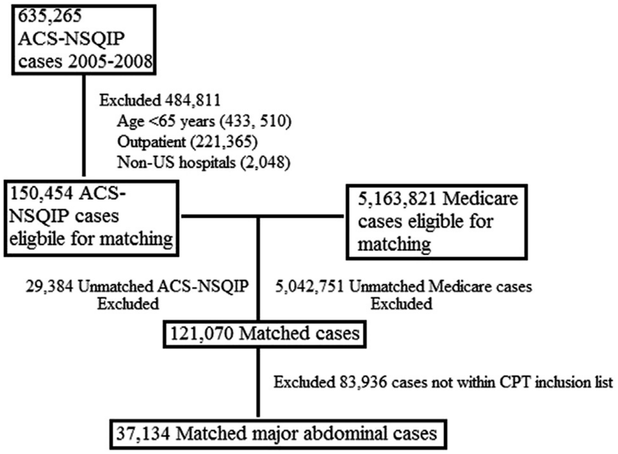
REFERENCES

1. Khuri SF, Daley J, Henderson WG. The comparative assessment and improvement of quality of surgical care in the Department of Veterans Affairs. Arch Surg 2002;137:20–27.
2. Khuri SF, Daley J, Henderson W, et al. The Department of Veterans Affairs' NSQIP: the first national, validated, outcome-based, risk-adjusted, and peer-controlled program for the measurement and enhancement of the quality of surgical care. National VA Surgical Quality Improvement Program. Ann Surg 1998;228:491–507.
3. Lawson EH, Ko CY, Louie R, et al. Linkage of a clinical surgical registry with Medicare inpatient claims data using indirect identifiers. Surgery 2013;153:423–430.
4. Khuri SF, Henderson WG, DePalma RG, et al. Determinants of long-term survival after major surgery and the adverse effect of postoperative complications. Ann Surg 2005;242:326–341; discussion 341–343.
5. Hannan EL, Kilburn H, Lindsey ML, Lewis R. Clinical versus administrative data bases for CABG surgery. Does it matter? Med Care 1992;30:892–907.
6. Romano PS, Chan BK, Schembri ME, Rainwater JA. Can administrative data be used to compare postoperative complication rates across hospitals? Med Care 2002;40:856–867.
7. Stevenson KB, Khan Y, Dickman J, et al. Administrative coding data, compared with CDC/NHSN criteria, are poor indicators of health care-associated infections. Am J Infect Control 2008;36:155–164.
8. Best WR, Khuri SF, Phelan M, et al. Identifying patient preoperative risk factors and postoperative adverse events in administrative databases: results from the Department of Veterans Affairs National Surgical Quality Improvement Program. J Am Coll Surg 2002;194:257–266.
9. Shahian DM, Silverstein T, Lovett AF, et al. Comparison of clinical and administrative data sources for hospital coronary artery bypass graft surgery report cards. Circulation 2007;115:1518–1527.
10. Lapar DJ, Stukenborg GJ, Lau CL, et al. Differences in reported esophageal cancer resection outcomes between national clinical and administrative databases. J Thorac Cardiovasc Surg 2012;144:1152–1157.
11. Huo J, Du XL, Lairson DR, et al. Utilization of surgery, chemotherapy, radiation therapy, and hospice at the end of life for patients diagnosed with metastatic melanoma. Am J Clin Oncol 2013. http://dx.doi.org/10.1097/COC.0b013e31829378f9.
12. Griffiths RI, Gleeson ML, Danese MD, O'Hagan A. Inverse probability weighted least squares regression in the analysis of time-censored cost data: an evaluation of the approach using SEER-Medicare. Value Health 2012;15:656–663.
13. Fisher ES, Whaley FS, Krushat WM, et al. The accuracy of Medicare's hospital claims data: progress has been made, but problems remain. Am J Public Health 1992;82:243–248.
14. Lawson EH, Louie R, Zingmond DS, et al. A comparison of clinical registry versus administrative claims data for reporting of 30-day surgical complications. Ann Surg 2012;256:973–981.
15. Joynt KE, Jha AK. Who has higher readmission rates for heart failure, and why? Implications for efforts to improve care using financial incentives. Circ Cardiovasc Qual Outcomes 2011;4:53–59.
16. Joynt KE, Orav EJ, Jha AK. Thirty-day readmission rates for Medicare beneficiaries by race and site of care. JAMA 2011;305:675–681.
17. Romano PS, Mark DH. Bias in the coding of hospital discharge data and its implications for quality assessment. Med Care 1994;32:81–90.
18. Stey AM, Ko CY, Hall BL, et al. Are procedures codes in claims data a reliable indicator of intraoperative splenic injury compared with clinical registry data? J Am Coll Surg 2014;219:237–244. e1.
19. Colavita PD, Tsirline VB, Belyansky I, et al. Prospective, long-term comparison of quality of life in laparoscopic versus open ventral hernia repair. Ann Surg 2012;256:714–722; discussion 722–723.
20. Helgstrand F, Rosenberg J, Kehlet H, et al. Nationwide prospective study of outcomes after elective incisional hernia repair. J Am Coll Surg 2013;216:217–228.
21. Ladurner R, Chiapponi C, Linhuber Q, Mussack T. Long term outcome and quality of life after open incisional hernia repair—light versus heavy weight meshes. BMC Surg 2011;11:25.
22. Anthony T, Bergen PC, Kim LT, et al. Factors affecting recurrence following incisional herniorrhaphy. World J Surg 2000;24:95–100; discussion 101.
23. Bansal VK, Misra MC, Babu D, et al. Comparison of long-term outcome and quality of life after laparoscopic repair of incisional and ventral hernias with suture fixation with and without tacks: a prospective, randomized, controlled study. Surg Endosc 2012;26:3476–3485.
24. Aalen OO. Heterogeneity in survival analysis. Stat Med 1988;7:1121–1137.
25. Aalen OO. Effects of frailty in survival analysis. Stat Methods Med Res 1994;3:227–243.
26. Liquet B, Timsit JF, Rondeau V. Investigating hospital heterogeneity with a multi-state frailty model: application to nosocomial pneumonia disease in intensive care units. BMC Med Res Methodol 2012;12:79.
27. Vignali A, De Nardi P, Ghirardelli L, et al. Short and long-term outcomes of laparoscopic colectomy in obese patients. World J Gastroenterol 2013;19:7405–7411.

28. Wormer BA, Walters AL, Bradley JF, et al. Does ventral hernia defect length, width, or area predict postoperative quality of life? Answers from a prospective, international study. J Surg Res 2013;184:169–177.
29. Fink C, Baumann P, Wente MN, et al. Incisional hernia rate 3 years after midline laparotomy. Br J Surg 2014;101:51–54.
30. Eker HH, Hansson BM, Buunen M, et al. Laparoscopic vs. open incisional hernia repair: a randomized clinical trial. JAMA Surg 2013;148:259–263.
31. Breuing K, Butler CE, Ferzoco S, et al. Incisional ventral hernias: review of the literature and recommendations regarding the grading and technique of repair. Surgery 2010;148:544–558.
32. Mudge M, Hughes LE. Incisional hernia: a 10 year prospective study of incidence and attitudes. Br J Surg 1985;72:70–71.
33. Stocchi L, Milsom JW, Fazio VW. Long-term outcomes of laparoscopic versus open ileocolic resection for Crohn's disease: follow-up of a prospective randomized trial. Surgery 2008;144:622–627; discussion 627–628.
34. Krausz MM, Duek SD. Restorative proctocolectomy with ileal pouch-anal anastomosis for ulcerative colitis and familial adenomatous polyposis: twenty years follow-up in 174 patients. Isr Med Assoc J 2005;7:23–27.
35. Mason RJ, Moazzez A, Sohn HJ, et al. Laparoscopic versus open anterior abdominal wall hernia repair: 30-day morbidity and mortality using the ACS NSQIP database. Ann Surg 2011;254:641–652.
36. Reynolds D, Davenport DL, Korosec RL, Roth JS. Financial implications of ventral hernia repair: a hospital cost analysis. J Gastrointest Surg 2013;17:159–166; discussion 166–167.
37. Poulose BK, Shelton J, Phillips S, et al. Epidemiology and cost of ventral hernia repair: making the case for hernia research. Hernia 2012;16:179–183.

Appendix 1. Current Procedural Terminology Codes of Index Operation Included in this Analysis

Procedure	CPT Code
Colectomy	
Colectomy, Partial; with anastomosis	41440
Colectomy, Partial; with skin level cecostomy or colostomy	44141
Colectomy, Partial; with end colostomy and closure of distal segment (Hartmann type procedure)	44143
Colectomy, Partial; with coloproctostomy (low pelvic anastomosis)	44145
Colectomy, Partial; with coloproctostomy (low pelvic anastomosis), with colostomy	44146
Colectomy, total, abdominal without proctectomy; with ileostomy or ileoproctostomy	44150
Colectomy, Partial, with removal of terminal ileum with ileocolostomy	44160
Laparoscopy, Surgical; colectomy, partial, with anastomosis	44204
Laparoscopy, Surgical; colectomy, partial, with removal of terminal ileum with ileocolostomy	44205
Laparoscopy, Surgical; colectomy, partial, with anastomosis, with coloproctostomy (low pelvic anastomosis)	44207
Cholecystectomy	
Cholecystectomy;	47600
Cholecystectomy; with cholangiography	47605
Laparoscopy, surgical; Cholecystectomy	47562
Laparoscopy, surgical; Cholecystectomy with cholangiography	47563
Small bowel resection	
Enterectomy, resection of small intestine; Single resection and anastomosis	44120
Closure of enterostomy, large or small intestine;	44620
Closure of enterostomy, large or small intestine; with resection and anastomosis other than colorectal	44625
Closure of enterostomy, large or small intestine; with resection and colorectal anastomosis (E.g., closure of Hartmann type procedure)	44626
Ventral hernia repair	
Repair initial incisional or ventral hernia; reducible	49560
Repair initial incisional or ventral hernia; incarcerated or strangulated	49561
Repair recurrent incisional or ventral hernia; reducible	49565
Repair recurrent incisional or ventral hernia; incarcerated of strangulated	49566
Pancreatectomy	
Pancreatectomy, distal subtotal, with or without splenectomy; without pancreaticojejunostomy	48140
Pancreatectomy, proximal subtotal with total duodenectomy, partial gastrectomy, choledochoenterostomy and gastrojejunostomy (whipple-type procedure)	48150
Pancreatectomy, proximal subtotal with near-total duodenectomy, choledochoenterostomy and duodenojejunostomy (pylorus-sparing, Whipple-type procedure)	48153



Appendix 2. Study Flow Diagram. ACS, American College of Surgeons.

Appendix 3. ICD-9 Codes Used to Define the Primary Outcomes of Long-Term Incisional Hernia Repair

International Classification of Disease 9	Descriptions
46.42	Pericolostomy hernia repair
53.49	Open umbilical hernia repair
53.51	Incisional hernia repair
53.59	Abdominal wall hernia repair
53.61	Open incisional hernia repair with graft
53.62	Laparoscopic incisional hernia repair with graft
53.69	Open hernia anterior abdominal wall graft
53.9	Other hernia repair
54.61	Reclose postoperative disruption
54.62	Delayed closure of the abdominal wound
54.72	Abdomen wall repair
83.65	Other fascial suture closure