ORIGINAL CONTRIBUTION

A National Database Analysis Comparing the Nationwide Inpatient Sample and American College of Surgeons National Surgical Quality Improvement Program in Laparoscopic vs Open Colectomies: Inherent Variance May Impact Outcomes

Andrew T. Schlussel, D.O.[1] • Conor P. Delaney, M.D.[2] • Justin A. Maykel, M.D.[1]
Michael B. Lustik, M.S.[3] • Madhuri Nishtala, B.S.[4] • Scott R. Steele, M.D.[4]

1 Division of Colorectal Surgery, University of Massachusetts Memorial Medical Center, Worcester, Massachusetts
2 Digestive Disease Institute, Cleveland Clinic, Cleveland, Ohio
3 Department of Clinical Investigation, Tripler Army Medical Center, Honolulu, Hawaii
4 Division of Colorectal Surgery, University Hospitals Case Medical Center, Cleveland, Ohio

BACKGROUND: Clinical and administrative databases each have fundamental distinctions and inherent limitations that may impact results.

OBJECTIVE: This study aimed to compare the American College of Surgeons National Surgical Quality Improvement Program and the Nationwide Inpatient Sample, focusing on the similarities, differences, and limitations of both data sets.

DESIGN: All elective open and laparoscopic segmental colectomies from American College of Surgeons National Surgical Quality Improvement Program (2006–2013) and Nationwide Inpatient Sample (2006–2012) were reviewed. *International Classification of Diseases, Ninth Revision, Clinical Modification* coding identified Nationwide Inpatient Sample cases, and *Current Procedural Terminology* coding for American College of Surgeons National Surgical Quality Improvement Program. Common demographics and comorbidities were identified, and in-hospital outcomes were evaluated.

SETTINGS: A national sample was extracted from population databases.

PATIENTS: Data were derived from the Nationwide Inpatient Sample database: 188,326 cases (laparoscopic = 67,245; open = 121,081); and American College of Surgeons National Surgical Quality Improvement Program: 110,666 cases (laparoscopic = 54,191; open = 56,475).

MAIN OUTCOME MEASURES: Colectomy data were used as an avenue to compare differences in patient characteristics and outcomes between these 2 data sets.

RESULTS: Laparoscopic colectomy demonstrated superior outcomes compared with open; therefore, results focused on comparing a minimally invasive approach among the data sets. Because of sample size, many variables were statistically different without clinical relevance. Coding discrepancies were demonstrated in the rate of conversion from laparoscopic to open identified in the National Surgical Quality Improvement Program (3%) and Nationwide Inpatient Sample (15%) data sets. The prevalence of nonmorbid obesity and anemia from National Surgical Quality Improvement Program was more than twice that of Nationwide Inpatient Sample. Sepsis was statistically greater in

Financial Disclosure: None reported.

Disclosure and Proprietary Statement: This is an original work by the above authors. The opinions expressed are the authors' and authors' alone. They do not necessarily reflect the opinion of the United States Government, the US Department of Defense, or US Army.

Podium presentation at The American Society of Colorectal Surgeons annual meeting, Los Angeles, CA, April 30 to May 4, 2016.

Correspondence: Scott R. Steele, M.D., Division of Colorectal Surgery, University Hospitals Case Medical Center, Case Western Reserve University, 11100 Euclid Ave, Cleveland, OH 44106. E-mail: harkersteele@mac.com

Dis Colon Rectum 2016; 59: 843–854
DOI: 10.1097/DCR.0000000000000642

National Surgical Quality Improvement Program, with urinary tract infections and acute kidney injury having a greater frequency in the Nationwide Inpatient Sample cohort. Surgical site infections were higher in National Surgical Quality Improvement Program (30-day) vs Nationwide Inpatient Sample (8.4% vs 2.6%; $p < 0.01$), albeit less when restricted to infections that occurred before discharge (3.3% vs 2.6%; $p < 0.01$).

LIMITATIONS: This is a retrospective study using population-based data.

CONCLUSION: This analysis of 2 large national databases regarding colectomy outcomes highlights the incidence of previously unrecognized data variability. These discrepancies can impact study results and subsequent conclusions/recommendations. These findings underscore the importance of carefully choosing and understanding the different population-based data sets before designing and when interpreting outcomes research.

KEYWORDS: Nationwide Inpatient Sample; National Surgical Quality Improvement Program; Population data; Colectomy; Outcomes; Laparoscopy.

As the national trend toward surgical quality improvement grows, the use of outcomes-based research has become paramount. Although well-controlled, prospective, randomized trials are ideal, their design and impact are often challenged by rapid advances in technology and continued innovation of new surgical techniques. Furthermore, as hospital reimbursement continues to be guided by operative success and pay-for-performance measures are implemented, the production of surgical outcomes research is necessary at a rapid pace. To help overcome the variable experience across a wide range of medical centers throughout the country, administrative and clinical registry data, such as the Nationwide Inpatient Sample (NIS) and American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) can provide a snapshot as to what takes place on a population-based level. Although they lack some of the specifics garnered by smaller studies and rely on accurate data entry, these databases allow for the inclusion of larger numbers of patients that may help account for the varying experience of many surgeons.

These databases are unique in design, with differing goals. An administrative database such as NIS is largely based on billing information, whereas a clinical database provides defined patient information. The NIS database is the largest all-payer inpatient care database in the United States including persons covered by Medicare, Medicaid, private insurance, and the uninsured, with data from over 8 million hospital admissions per year. The NIS is part of the Healthcare Cost and Utilization Project and sponsored by the Agency for Healthcare Research and Quality. This data set allows for accurate national estimates from approximately 20% of all discharges nationwide. It includes admission and discharge diagnoses, procedures performed, complications, and outcome data during the hospitalization.[1] The ACS-NSQIP, initially designed for quality improvement within the Veterans Affairs health system, is a validated risk-adjusted outcomes database that focuses on perioperative variables to include preoperative factors, specific surgical interventions and care, and 30-day postoperative results.[2,3] It also provides a slightly different level of granularity than NIS. Yet, the wealth of information provided by each database provides a means to investigate pathology, complications, or procedures at a multi-institutional level, and these databases provide a platform to establish benchmarks to measure the quality of patient care.[4–6]

The safety and efficacy of a laparoscopic colectomy for both benign and malignant disease has been well established.[7–10] In addition, the authors have previously demonstrated this at a national level by using NIS, for both segmental resections (right, left, and sigmoid colectomy) and more complex operations.[11,12] However, inherent differences exist in each data set, including what they measure and how the data are captured, leading to variability that may impact study results. The specific aim of this study is to provide a comparative analysis of demographics, comorbidities, and outcomes between the NIS and NSQIP databases, through the evaluation of laparoscopic segmental colectomies, to further elucidate the variation between these 2 large, well-established and highly used data sets.

METHODS

The Institutional Review Board at Tripler Army Medical Center, Honolulu, Hawaii, approved the study protocol. Investigators adhered to the policies for protection of human subjects as prescribed in 45 Code of Federal Regulation 46. A retrospective analysis was performed of patients undergoing an elective segmental colectomy identified in the NIS (2006–2012) and from ACS-NSQIP (2006–2013). The NIS database uses primary *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) procedure codes to identify a segmental colectomy and includes: laparoscopic (17.33)/open (45.73) right, laparoscopic (17.35)/open (45.75) left, and laparoscopic (17.36)/open (45.76) sigmoid colectomy. Before 2008, a laparoscopic procedure was documented based on the laparoscopic designation code 54.21. Current Procedural Terminology (CPT) codes identified laparoscopic and open segmental colectomy cases in the ACS-NSQIP database 44204, 44205, 44206, 44213, 44140, 44141, 44143, 44144, 44160, 44139) (Appendix A). Clinically relevant surgical indications were identified based on *ICD-9-CM* coding and include diverticular disease, colon cancer, benign colonic neoplasms and inflammatory bowel disease.

Definition of Variables

The primary variables in this study were the technical approach (laparoscopic colectomy) and site of resection. The operation was based on the originally intended procedure, with cases that converted from laparoscopic to open treated as laparoscopic for analysis. A diagnostic code of v64.41 was used to identify conversions in NIS. In NSQIP, a case was treated as a conversion if the primary CPT code (final procedure) was open and one of the secondary CPT codes (based on the OTHERCPT and CONCPT variables) contained a corresponding laparoscopic procedure.

Demographic data collected by NIS and NSQIP included age (years), sex, and race. Hospitals were classified by teaching status (teaching, nonteaching) and location (urban, rural). Teaching status in NSQIP was based on the "Attend" variable. Cases coded as attending and resident in the operating room or attending not present but available were classified as cases done at a teaching hospital. Eight clinically relevant comorbidities that could be readily compared between both databases were identified. These included anemia, coagulopathy, nonmorbid obesity (BMI 30–39.9 kg/m^2), morbid obesity (BMI ≥40 kg/m^2), weight loss, peripheral vascular disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes mellitus, and hypertension (Appendix B). Ostomy placement in the NIS was determined using *ICD-9-CM* procedure code 46.03, 46.01, 46.1, and 46.2; in NSQIP, stoma formation is designated within the segmental colectomy CPT code.

Main Outcome

Morbidity and Mortality

We classified NSQIP adverse events as both before discharge and up to 30 days postoperatively based on the yes/no indicator for each complication, days until complication, and days until discharge. By contrast, NIS only includes data for in-hospital complications. NSQIP follows each patient for specific complications, whereas NIS captures up to 25 *ICD-9-CM* diagnosis codes for each patient. To compare rates between databases, we used the *ICD-9-CM* groupings previously published by Bohl et al[5] to help standardize definitions (Appendix C).

Length of Hospital Stay

The length of the hospital stay was measured in days from the time of admission to the time of discharge.

Statistical Analysis

All statistical analysis was performed using SAS version 9.2 (SAS Institute, Inc, Cary, NC). For unadjusted analyses, χ^2 analysis was used to compare categorical variables between the NIS and NSQIP databases, and Student *t* tests were used to compare continuous variables. Median and interquartile (IQR) ranges were used to summarize skewed variables such as length of stay (LOS). For multivariable analysis, Poisson regression with robust error variance was used to estimate an adjusted relative risk and 95% CI with NIS as the reference point. A significance level of $p < 0.05$ was used for all analyses. Statistical power to detect relatively small differences was high because of the large sample sizes for both databases.

RESULTS

Patient Demographics

We identified a total of 188,326 cases in the NIS database and 110,666 in the ACS-NSQIP (Table 1). Laparoscopic surgeries accounted for 36% (n = 67,245) of all NIS surgeries and nearly half, 49% (n = 54,191) of all NSQIP surgeries. Age and sex distributions were similar between databases. The median age of patients was 64 for both databases (IQR = 53–74 for NIS and 53–75 for NSQIP), and slightly more than half of patients (53%) were female in both databases. Race was more likely to be unknown for NIS than for NSQIP (18% vs 5%; $p < 0.01$). Less than half of NIS cases were performed at teaching hospitals in comparison with nearly two-thirds of NSQIP cases (46% vs 65%; $p < 0.01$). Although the demographics among these populations were relatively similar, the frequency of all comorbidities varied statistically, with the exception of weight loss; the greatest difference was identified for cases with anemia (18.6% vs 49.9%; $p<0.01$) and nonmorbid obesity (7.0% vs 26.9%; $p < 0.01$) in NIS and NSQIP. Median (IQR) LOS was similar between both data sets, 5 (4–7.5) days in NIS and 5.5 (4–7.5) days in NSQIP. All demographics and comorbidities were statistically different between the laparoscopic and open approach within each database, and the laparoscopic approach was associated with superior clinical outcomes.

Operative Procedures

A focused analysis of laparoscopic segmental colectomy cases was then performed. In the NIS database, we identified a right colectomy in 47% of cases (31,437), a sigmoid colectomy in 44% (29,250), and a left colectomy in 10% (6,558). The conversion rate from laparoscopic to open was 15%, and an ostomy was created in 3.8% of cases. The NSQIP database identified segmental colectomy as either partial colectomy (68%, n = 35,901), partial colectomy with removal of terminal ileum (29%, n = 5470), or partial colectomy with end colostomy (2%, n = 1249). The rate of conversion to an open procedure was 3%. Univariate analysis of demographics and comorbidities are represented in Table 2. As previously depicted in the total population, the rate of unknown race is significantly greater in NIS than

TABLE 1. Demographics and comorbidities of study population (laparoscopic + open)

	NIS n (weighted %)	NSQIP n (%)	p
Total cases	188,326	110,666	
Sex			
Female	100,854 (53.6)	58,651 (53.1)	**<0.01**
Male	87,223 (46.4)	51,850 (46.9)	
Race			
White	126,079 (66.9)	82,256 (74.3)	**<0.01**
Black	13,084 (6.9)	9962 (9)	
Hispanic	9349 (5)	5179 (4.7)	
Other	6705 (3.6)	8230 (7.4)	
Unknown	33,109 (17.6)	5039 (4.6)	
Age			
18–44	18,421 (9.8)	12,764 (11.5)	**<0.01**
45–64	74,855 (39.7)	43,106 (39)	
65–74	47,531 (25.2)	26,512 (24)	
75+	47,519 (25.2)	28,284 (25.6)	
Teaching hospital			
Yes	86,780 (46.4)	42,591 (65)	**<0.01**
No	100,191 (53.6)	22,954 (35)	
Comorbidities			
Anemia	35,039 (18.6)	52,935 (49.9)	**<0.01**
Coagulopathy	3819 (2)	4813 (4.3)	**<0.01**
Nonmorbid obesity[a]	13,150 (7.0)	29,654 (26.9)	**<0.01**
Morbid obesity[b]	6522 (3.5)	5958 (5.5)	**<0.01**
Weight loss	9245 (4.9)	5592 (5.1)	0.08
Peripheral vascular disease	6341 (3.4)	1003 (0.9)	**<0.01**
Congestive heart failure	9744 (5.2)	1256 (1.1)	**<0.01**
COPD	16,533 (8.8)	6464 (5.8)	**<0.01**
Diabetes mellitus	32,508 (17.3)	17,430 (15.8)	**<0.01**
Hypertension	95,960 (51)	57,975 (52.4)	**<0.01**

COPD = chronic obstructive pulmonary disease; NIS = Nationwide Inpatient Sample; NSQIP = National Surgical Quality Improvement Program.
[a]Nonmorbid obesity = BMI of 30–39.9 kg/m^2.
[b]Morbid obesity = BMI ≥ 40 kg/m^2.

in NSQIP, and there are a significantly greater number of teaching institutions recorded for laparoscopic cases from the NSQIP database.

Comorbidities

Comorbidity rates were divided into 2 groups based on variables that had a 2-fold difference. The documented rate of peripheral vascular disease and congestive heart failure, albeit low, was more than twice that in the NIS than in the NSQIP. The prevalence of anemia and nonmorbid obesity in NSQIP was twice that in the NIS database. The remaining comorbidities were within a 2-fold difference of each other (Table 2 and Fig. 1). A relative difference in rates between data sources comparing comorbidities in NIS vs NSQIP was evaluated, and the majority of differences persisted following an adjusted analysis (Fig. 2).

Outcomes

In-hospital adverse events were compared between NIS and NSQIP. Overall, the rate of morbidity was low. The risk of mortality before discharge was 0.5% in both NIS and NSQIP ($p = 0.64$), but this reached an incidence of 0.9% at 30 days in the NSQIP database. The majority of postoperative complications before discharge did not differ more than 2-fold between data sets. The development of acute kidney injury (AKI) (2.1% vs 1.1%; $p<0.01$) and a urinary tract infection (UTI) (2.2% vs 1.1%; $p < 0.01$) recorded in NIS was twice that of the NSQIP population (Fig. 3). Poisson regression analysis was performed to estimate the relative risks of complications before discharge. The risk of stroke, postoperative intubation, myocardial infarction, wound disruption, and death was equivalent. The NIS cohort was associated with a lower rate of surgical site infection (SSI), deep vein thrombosis, sepsis, and cardiac arrest, with a significantly greater risk of AKI, UTI, pulmonary embolism, and pneumonia (Fig. 4).

As expected, the rate of adverse events in the entire NSQIP subset increased after discharge. The outcomes recorded in NSQIP after discharge from the hospital and within 30 days of surgery were evaluated. The incidence of surgical site infections after discharge was significantly greater than while the patient was in the hospital (5.2% vs 3.3%; $p < 0.01$) (Fig. 5).

TABLE 2. Demographics and comorbidities of laparoscopic segmental colectomy

	NIS n (weighted %)	*NSQIP n (%)*	*p*
Total cases	67,245	54,191	
Sex			
Female	35,330 (52.6)	28,490 (52.7)	0.84
Male	31,799 (47.4)	25,584 (47.3)	
Race			
White	48,454 (72.1)	40,703 (75.1)	**<0.01**
Black	4893 (7.3)	4457 (8.2)	
Hispanic	3812 (5.7)	2752 (5.1)	
Other	2582 (3.8)	4180 (7.7)	
Unknown	7504 (11.2)	2099 (3.9)	
Age			
18–44	7250 (10.8)	6235 (11.5)	**<0.01**
45–64	29,342 (43.6)	22,213 (41)	
65–74	16,883 (25.1)	13,424 (42.8)	
75+	13,770 (20.5)	12,319 (22.7)	
Teaching hospital			
Yes	33,850 (50.8)	18,634 (63.9)	**<0.01**
No	32,791 (49.2)	10,536 (36.1)	
Indications for surgery			
Diverticular	25,973 (38.6)	11,045 (20.4)	**<0.01**
Colon cancer	23,038 (34.3)	20,336 (37.5)	**<0.01**
Benign neoplasm	14,773 (22)	11,184 (20.6)	**<0.01**
IBD	989 (1.5)	1295 (2.4)	**<0.01**
Comorbidities			
Anemia	10,110 (15)	20,803 (40.4)	**<0.01**
Coagulopathy	992 (1.5)	1568 (2.9)	**<0.01**
Nonmorbid obesity[a]	5563 (8.3)	15,189 (28.2)	**<0.01**
Morbid obesity[b]	2634 (3.9)	2600 (4.8)	**<0.01**
Weight loss	1767 (1.6)	1587 (2.9)	**<0.01**
Peripheral vascular disease	1825 (2.7)	296 (0.5)	**<0.01**
Congestive heart failure	2152 (3.2)	387 (0.7)	**<0.01**
COPD	4521 (6.7)	2427 (4.5)	**<0.01**
Diabetes mellitus	10,992 (16.3)	7926 (14.6)	**<0.01**
Hypertension	33,757 (50.2)	27,684 (51.1)	**<0.01**

COPD = chronic obstructive pulmonary disease; NIS = Nationwide Inpatient Sample; NSQIP = National Surgical Quality Improvement Program.
[a]Nonmorbid obesity = BMI of 30–39.9 kg/m^2.
[b]Morbid obesity = BMI ≥ 40 kg/m^2.

DISCUSSION

The implementation of national databases has gained rapid popularity as a means to evaluate surgical outcomes on a large scale, and conclusions are being drawn from these well-powered results that may alter the way surgical care is administered. However, there are significant disparities among both clinical and administrative data sets that extend beyond NIS and ACS-NSQIP.[6,13,14] In addition, findings from populations-based data have been called into question in comparison with prospective well-controlled randomized investigations, suggesting the use of caution when interpreting these results.[15] Nevertheless, outcomes-based research is an ideal tool to evaluate our success in minimizing postoperative complications following elective colectomy. These quality benchmarks in the perioperative setting affect both patient outcomes and reimbursement, and should be studied nationwide.[16]

This study demonstrates 2 cohorts of patients, undergoing a common surgical procedure, over a similar time period, identified over 2 differently designed databases that acquired patient information for separate reasons. Table 3 summarizes fundamental differences among the databases, as well as strengths of each database derived based on this comparison. The objective of this study was not to demonstrate the results of laparoscopic colectomy, but to use this procedure as an avenue to compare differences in what "should" be equivalent outcomes between these 2 data sets. The similarities among the demographics reported allow for an optimal means to compare these databases. Small differences observed were statistically different because of the large sample size. Even though the discrepancies observed are clinically inconsequential, the knowledge of these variations may aid in accurately deciding on a database to study based on the objectives desired. Variation in comorbidities and adverse events that demonstrated a 2-fold difference does bring into some question the validity in which data were captured, and the definitions of each variable may play a role in identifying a

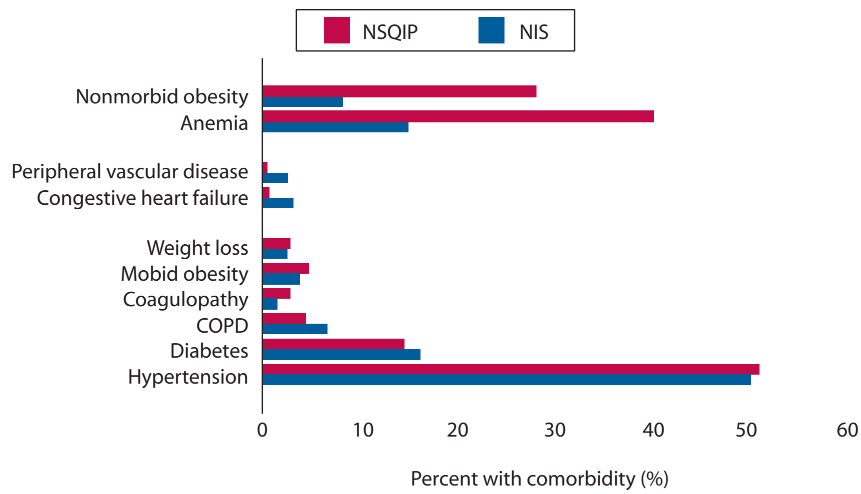

FIGURE 1. Rate of comorbidities in laparoscopic segmental colectomy. All comparisons are significantly different, $p < 0.05$. COPD = chronic obstructive pulmonary disease; NIS = Nationwide Inpatient Sample; NSQIP = National Surgical Quality Improvement Program.

particular comorbidity or outcome. The NIS is populated from administrative data sets entered by trained hospital coding specialists for billing purposes and reimbursement. This database is fraught with potential for coding entry error, because the information is only as good as the standard of physician chart documentation and hospital billing codes. Such administrative databases therefore are recognized to have lower incidences of complications such as wound infection, which might be collected prospectively in NSQIP. In addition, the NIS is unable to evaluate outcomes following discharge, and therefore may underrepresent those complications that have a greater risk of developing after the patient leaves the hospital. Despite these limitations, this database provides a representation of how surgery is being practiced across the country, and also collects data on every patient who goes through the hospital, rather than a random sample of less then 25% of total cases. The NIS had about a 2-fold difference in the incidence of open operations compared with NSQIP, a finding that may be more consistent with national trends. A recent study by Moghadamyeghaneh and colleagues[17] supports these findings, demonstrating that only about one-half of the colon resections in the United States are performed laparoscopically. Academic institutions were also documented at a greater frequency in the NSQIP database, and this may influence the operative approach in an era of advanced laparoscopic training.

The ACS-NSQIP was specifically designed to collect clinical data for quality improvement and research purposes. This database has been well validated, and its methods of data collection provide a reliable resource to investigate surgical outcomes[18,19] The information acquired allows hospitals to develop a better understanding of their complications and foster a goal of improving surgical care. The data provide information over a wide breathe of cases up to 30 days following surgery.

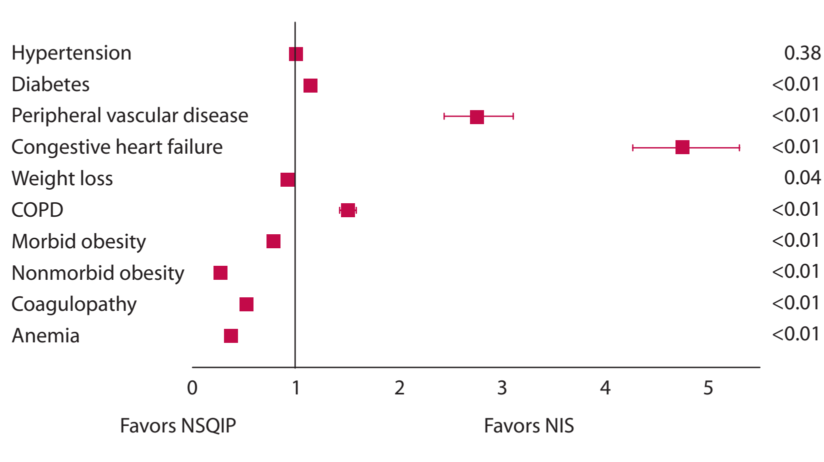

FIGURE 2. Relative difference in rates between data sources comparing comorbidities in NIS to the NSQIP database. COPD = chronic obstructive pulmonary disease; NIS = Nationwide Inpatient Sample; NSQIP = National Surgical Quality Improvement Program.

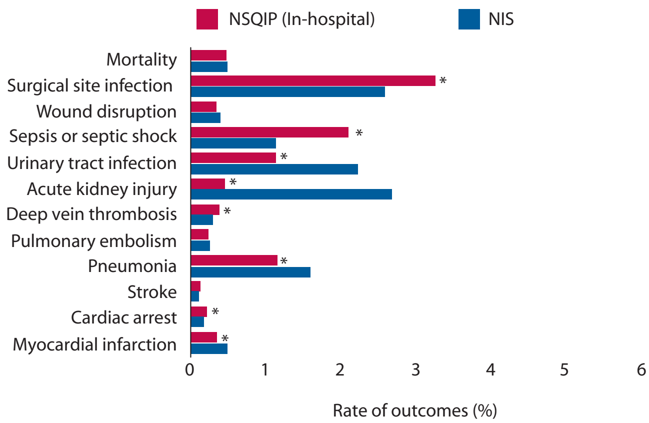

FIGURE 3. Rate of in-hospital adverse events for laparoscopic segmental colectomy. *$p < 0.05$. NIS = Nationwide Inpatient Sample; NSQIP = National Surgical Quality Improvement Program.

Unlike NIS, data collection for NSQIP is assessed by well-trained surgical clinical nurse reviewers who conduct a directed thorough review of medical records, and then undergo quality control measures to ensure the accuracy of the data presented. NSQIP provides a valuable means to perform a risk-adjusted analysis, and its ability to directly abstract clinical information may afford a more focused understanding patient's health.[3,20] Although the methods of data collection may be superior, NSQIP has not been implemented in all hospital systems. Participation comes with a cost, and as of 2013 only 435 hospitals across the nation participate in NSQIP.[2] The data variability in the rate of comorbidities and outcomes between NIS and NSQIP may be secondary to the relative underpowered nature of NSQIP. Furthermore, NSQIP only collects data on a small subset of cases done at any institution. However, for those particular surgical specialties and cases, the ACS-NSQIP may be the preferred database to use when attempting to evaluate specific clinical outcomes.

In this study there were 77,660 fewer cases in NSQIP than in NIS, and, before 2013, only a selected number of colectomies per week were being targeted for data collection. Therefore the number of actual cases, even in NSQIP-affiliated centers, was underrepresented. Furthermore, the rate of conversion from a laparoscopic to open procedure in NSQIP was only 3%, compared with 15% from the NIS data set. Previous studies have confirmed a greater incidence of conversion.[21,22] In a recent study evaluating factors associated with a conversion from laparoscopic to open using the NSQIP database, Bhama and colleagues[23] reported a rate of 5.8%, whereas Moghadamyeghaneh et al[17] reports a rate of 12.8% and 11.9% from the NIS when evaluating colon cancer and diverticular resections. Bhama's study includes total abdominal colectomy cases, which may be associated with a greater conversion rate compared with our results.[23] Furthermore, the lower frequency of conversions in NSQIP may also be a factor of hospital participation, coding error, or skewed by the fact that NSQIP is coded by CPT codes, and conversions may be placed into the open case category because there is no CPT "conversion" code. This is compared with an *ICD-9-CM* conversion designator code that is present in NIS. This value may also reflect the different practices of surgeons from high-volume academic centers, with greater experience in laparoscopy and possibly a lower risk of conversion because of the skill set. However, this may not mirror what occurs across the nation. Although proposing specific clinical questions may be better answered through NSQIP, analyzing broader and more generalizable trends is well suited for the NIS database.

Over the next few years, the clinical data generated from the NSQIP database should dramatically improve with the recent implementation of procedure-targeted information. The ACS-NSQIP Procedure Targeted option has been created to allow hospitals to collect data on more than 30 high-risk, high-volume procedures drawn

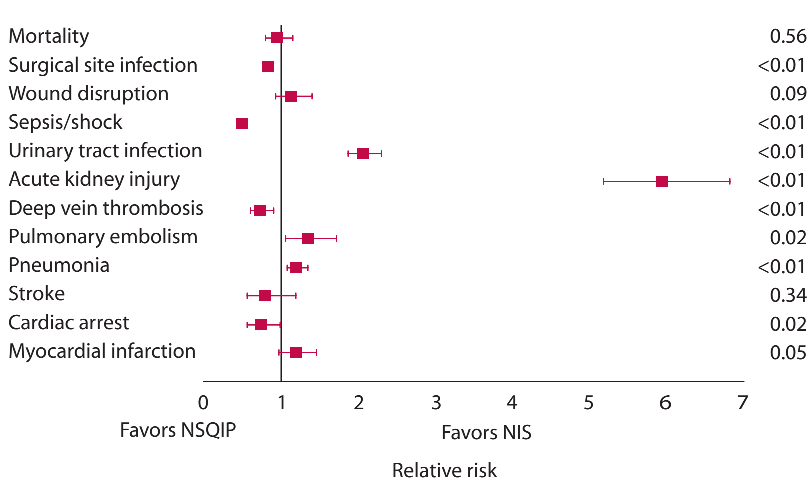

FIGURE 4. Relative risk of in-hospital adverse events in NIS compared with NSQIP database. NIS = Nationwide Inpatient Sample; NSQIP = National Surgical Quality Improvement Program.

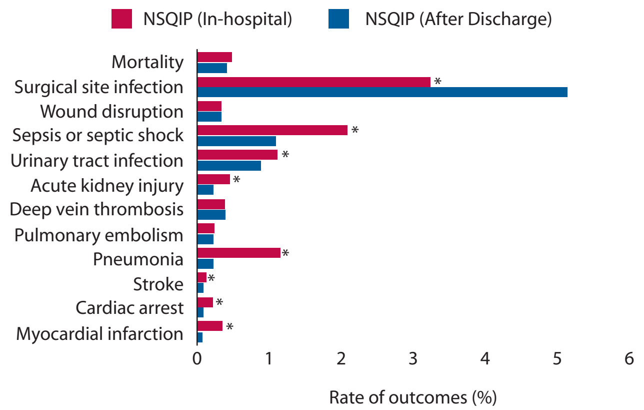

FIGURE 5. Rate of adverse events after discharge in NSQIP for laparoscopic segmental colectomy. *$p < 0.05$. NIS = Nationwide Inpatient Sample; NSQIP = National Surgical Quality Improvement Program.

from 9 subspecialty areas, including colectomies. This enhancement to the classic database will allow institutions to focus their quality improvement efforts, and will allow researchers to capture an even greater number of clinical data points from all colon resections and not just a selected number of cases. Examples of updated variables include the type of mechanical bowel preparation, specific data on tumor margin and pathology, as well as anastomotic leak rate.[2]

In regard to comorbidities, we aimed to evaluate 8 common comorbidities that may be associated with surgical outcomes, and have previously been used for directed database comparisons.[4,5] Because of the robust sample size, both databases differed significantly. However, the rate of preoperative anemia and nonmorbid obesity (BMI 30–39.9 kg/m^2) in NSQIP had a reported prevalence twice that of the NIS database. Interestingly, Bohl and colleagues[5] reported similar findings in a comparison of NIS and NSQIP through an evaluation of hip fractures. These analogous results suggest that the variability in these comorbidities is secondary to the method of capturing and coding this information. Data elements from NIS used to identify comorbidities are based on variables derived from proprietary software, and, when variables were not present, *ICD-9-CM* codes were selected to provide data comparable to NSQIP. This varies from NSQIP, which uses height and weight to directly document BMI, and a preoperative hematocrit <41% in men and <36% in women to indicate anemia. Therefore, in NIS, if anemia and obesity are not coded from the patient's chart, they will not be reported in the database. These findings caution the pursuit of research to evaluate the effects of anemia or obesity on surgical outcomes, because they may not be adequately powered through the NIS.

TABLE 3. Summary of differences and benefits of the NIS and NSQIP data sets

NIS	*NSQIP*
Retrospective	Prospective
Based on *ICD-9-CM* procedure codes with no CPT codes	Based on CPT codes with only 1 *ICD-9-CM* diagnosis code per case
Ability to study reimbursement data based on *ICD-9-CM* coding	Directed review of medical records by specially trained surgical clinical reviewers
Inpatient only	Inpatient and outpatient up to the 30th postoperative day
Captures a larger population with multiple diagnosis codes	Evaluation of academic institutions
National trends with a greater number of cases	Better suited for quality improvement research
Conversion rates	Specific patient characteristics and clinical outcomes data • Comorbidities: anemia and obesity • Adverse events: urinary tract infections and acute kidney injury
Surgical site infection for prolonged length of stay	Surgical site infection for short length of stay

CPT = Current Procedural Terminology; *ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification*; NIS = Nationwide Inpatient Sample; NSQIP = National Surgical Quality Improvement Program.

An analysis of postoperative complications including mortality demonstrates discordance in the 2 databases, indicating these inaccuracies may also be a consequence of the methods used for data acquisition. However, the frequency of greater than half of the adverse events evaluated were <1% in both NIS and before discharge NSQIP data sets. Although these values are statistically different, again they are likely not clinically relevant. In addition, only AKI and UTI differed more than 2-fold, with a higher rate of occurrence in the NIS database. These results have been observed in additional studies comparing NIS and NSQIP, and are most likely attributed to the methods of coding and documenting these complications.[5,24] The NSQIP variable for postoperative AKI and UTI requires specific clinical symptoms and laboratory values to be indicated in the medical records; however, in the NIS, these complications are simply defined based on *ICD-9-CM* coding. The challenge of using an administrative database that was not designed to measure clinical outcomes is discerning the accuracy of these results. Coding entry is not correlated to the time of diagnosis; therefore, it is unclear if the event occurred preoperatively or postoperatively, and this may result in an inaccurate representation of postoperative UTIs. To counter this, broad postoperative complication codes are available in NIS, and have been used previously to represent these adverse events.[11,12] However, the frequency of each subgroup of complications in this coded category is not specifically identified. To best match our comparisons between databases this code was not included.

With the advent of enhanced recovery protocols, the length of stay following colectomy has significantly decreased over time.[25] This shortened hospital stay ultimately benefits the patient; however, the role of studying postoperative complications using the NIS database becomes less effective, because many complications may not be evident within the first few postoperative days. Before discharge, our study demonstrated a SSI rate of 2.6% in NIS, and 3.3% in NSQIP, a finding that may be statistically different, but only varies by 0.7%. However, 5.2% of SSIs are not recognized until after discharge based on NSQIP results, which is twice the rate of NIS-documented infections. This finding is consistent with previous studies demonstrating a significant association with the development of a SSI after leaving the hospital.[5,26] Surgical site infections are a highly scrutinized adverse event, and they have become a significant focus in outcomes-based research.[27,28] The NIS may not be the optimal database to evaluate the risk of SSI, because the majority of infections appear to occur following discharge. In addition, NSQIP provides the benefit of defining the location of the SSI: superficial, deep, or organ space infection, each of which may require a different management strategy. Thus, it may be more appropriate to use the NIS database to evaluate the rate of SSI following colorectal procedures with a longer LOS, such as pelvic dissections or nonelective cases, as has been demonstrated through the risk-adjusted analysis of superficial and deep wound infections following pancreaticoduodenectomy.[24]

There are inherent limitations to this study of population-based data. First, an administrative database such as the NIS has the potential for data entry error, missing data, and selection bias. There is also an innate selection bias in both a clinical and administrative data set that cannot be accounted for from each institution's pooled data, which may result in multiple unmeasured confounders. The methodology of the NIS is based on a goal of reimbursement, and this may result in comorbidities and complications being undercoded compared with a clinical registry. Furthermore, potentially important patient characteristics, perioperative risk factors, and outcomes may not be included in the database's software, and a review of medical records, even in a subset of these patients, cannot be performed.

Our study design compared 2 cohorts of a similar surgical procedure over 2 separate databases. The *ICD-9-CM* procedure codes and CPT codes cannot be directly matched, and therefore this may risk comparing nonequivalent variables. This discrepancy may also be highlighted in the means to identify stoma creation and conversion to an open operation, where different strategies are used to capture these events. In NSQIP, ostomy formation is a procedure embedded in the operative CPT codes, and conversion is based on identifying 2 distinct operative codes. This is compared with NIS where both are documented by *ICD-9-CM* coding which may provide ease in evaluating these procedures. Despite this, we used published methods in the current literature to allow for the most accurate comparison of comorbidities and outcome parameters, and our representation of similar demographics suggests these were comparable groups. In addition, the *ICD-9-CM* procedure-coding scheme results in limitations from the NIS database. At present, *ICD-9-CM* codes allow for the identification of laparoscopic operations; however, before 2008, a designation code was required. Previous studies have successfully used this code, so it was implemented in this study to maximize the number of cases evaluated.[12] Recently, hospital systems have converted to *International Classification of Diseases, 10th Revision*, a coding system that may provide more precise detail, but this will result in challenges to compare additional NIS year groups.

In addition, there is variability in surgical technique and skill throughout these large databases that cannot be accounted for in metrics alone. Although not designed to evaluate clinical outcomes, results from the NIS may demonstrate a more accurate representation as to what is occurring across the country, and not only at high-volume academic centers. The NSQIP provides the benefit of producing quality risk-adjusted information from a clinically designed database. Even though the methods of an administrative database may limit the type of complications that can be analyzed, the large sample size derived from NIS may function best to evaluate national trends of in-patient outcomes.

CONCLUSION

This analysis of 2 large national databases highlights the incidence of previously unrecognized data variability and discrepancy. We have demonstrated that *ICD-9-CM* coding to characterize patient comorbidities and postoperative outcomes often yields differing results than a well-validated clinically designed database. This variance can impact study results and subsequent conclusions or recommendations. These findings underscore the importance of carefully choosing and understanding the different population-based data sets before designing a study, and using caution when interpreting the results of outcomes-based research.

REFERENCES

1. Agency for Healthcare Research and Quality. Healthcare Cost and Utilization Project (HCUP). Introduction to the HCUP nationwide inpatient sample 2011. http://www.hcup-us.ahrq.gov. Accessed February 8, 2016.
2. American College of Surgeons National Surgical Quality Improvement Program. Available at: https://www.facs.org/quality-programs/acs-nsqip. Accessed July 2015.
3. Weiss A, Anderson JE, Chang DC. Comparing the National Surgical Quality Improvement Program with the Nationwide Inpatient Sample Database. *JAMA Surg*. 2015;150:815–816.

4. Bohl DD, Russo GS, Basques BA, et al. Variations in data collection methods between national databases affect study results: a comparison of the nationwide inpatient sample and national surgical quality improvement program databases for lumbar spine fusion procedures. *J Bone Joint Surg Am*. 2014;96:e193.
5. Bohl DD, Basques BA, Golinvaux NS, Baumgaertner MR, Grauer JN. Nationwide Inpatient Sample and National Surgical Quality Improvement Program give different results in hip fracture studies. *Clin Orthop Relat Res*. 2014;472:1672–1680.
6. Lapar DJ, Stukenborg GJ, Lau CL, Jones DR, Kozower BD. Differences in reported esophageal cancer resection outcomes between national clinical and administrative databases. *J Thorac Cardiovasc Surg*. 2012;144:1152–1157.
7. Clinical Outcomes of Surgical Therapy Study Group. A comparison of laparoscopically assisted and open colectomy for colon cancer. *N Engl J Med*. 2004;350:2050–2059.
8. Parnaby CN, Ramsay G, Macleod CS, Hope NR, Jansen JO, McAdam TK. Complications after laparoscopic and open subtotal colectomy for inflammatory colitis: a case-matched comparison. *Colorectal Dis*. 2013;15:1399–1405.
9. Messenger DE, Mihailovic D, MacRae HM, O'Connor BI, Victor JC, McLeod RS. Subtotal colectomy in severe ulcerative and Crohn's colitis: what benefit does the laparoscopic approach confer? *Dis Colon Rectum*. 2014;57:1349–1357.
10. Seifarth C, Ritz JP, Kroesen A, Buhr HJ, Groene J. Effects of minimizing access trauma in laparoscopic colectomy in patients with IBD. *Surg Endosc*. 2015;29:1413–1418.
11. Schlussel AT, Lustik MB, Johnson EK, et al. Do the advantages of a minimally invasive approach remain in complex colorectal procedures? A nationwide comparison. *Dis Colon Rectum*. 2015;58:431–443.
12. Steele SR, Brown TA, Rush RM, Martin MJ. Laparoscopic vs open colectomy for colon cancer: results from a large nationwide population-based analysis. *J Gastrointest Surg*. 2008;12:583–591.
13. Aiello FA, Shue B, Kini N, et al. Outcomes reported by the Vascular Quality Initiative and the National Surgical Quality Improvement Program are not comparable. *J Vasc Surg*. 2014;60:152–9, 159.e1.
14. Rosales-Velderrain A, Bowers SP, Goldberg RF, et al. National trends in resection of the distal pancreas. *World J Gastroenterol*. 2012;18:4342–4349.
15. Hertzer NR. The Nationwide Inpatient Sample may contain inaccurate data for carotid endarterectomy and carotid stenting. *J Vasc Surg*. 2012;55:263–266.
16. Chen F, Shivarani S, Yoo J. Current status of quality measurement in colon and rectal surgery. *Clin Colon Rectal Surg*. 2014;27:10–13.
17. Moghadamyeghaneh Z, Carmichael JC, Mills S, Pigazzi A, Nguyen NT, Stamos MJ. Variations in laparoscopic colectomy utilization in the United States. *Dis Colon Rectum*. 2015;58:950–956.
18. Shiloach M, Frencher SK Jr, Steeger JE, et al. Toward robust information: data quality and inter-rater reliability in the American College of Surgeons National Surgical Quality Improvement Program. *J Am Coll Surg*. 2010;210:6–16.
19. Lawson EH, Zingmond DS, Hall BL, Louie R, Brook RH, Ko CY. Comparison between clinical registry and Medicare claims data on the classification of hospital quality of surgical care. *Ann Surg*. 2015;261:290–296.
20. Atherly A, Fink AS, Campbell DC, et al. Evaluating alternative risk-adjustment strategies for surgery. *Am J Surg*. 2004;188:566–570.
21. Keller DS, Khorgami Z, Swendseid B, et al. Laparoscopic and converted approaches to rectal cancer resection have superior long-term outcomes: a comparative study by operative approach. *Surg Endosc*. 2014;28:1940–1948.
22. Juo YY, Hyder O, Haider AH, Camp M, Lidor A, Ahuja N. Is minimally invasive colon resection better than traditional approaches?: first comprehensive national examination with propensity score matching. *JAMA Surg*. 2014;149:177–184.
23. Bhama AR, Charlton ME, Schmitt MB, Cromwell JW, Byrn JC. Factors associated with conversion from laparoscopic to open colectomy using the National Surgical Quality Improvement Program (NSQIP) database. *Colorectal Dis*. 2015;17:257–264.
24. Enomoto LM, Hollenbeak CS, Bhayani NH, Dillon PW, Gusani NJ. Measuring surgical quality: a national clinical registry versus administrative claims data. *J Gastrointest Surg*. 2014;18:1416–1422.
25. Alvarez MP, Foley KE, Zebley DM, Fassler SA. Comprehensive enhanced recovery pathway significantly reduces postoperative length of stay and opioid usage in elective laparoscopic colectomy. *Surg Endosc*. 2015;29:2506–2511.
26. Wiseman JT, Fernandes-Taylor S, Barnes ML, et al. Predictors of surgical site infection after hospital discharge in patients undergoing major vascular surgery. *J Vasc Surg*. 2015;62:1023–1031.e5.
27. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for Prevention of Surgical Site Infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. *Am J Infect Control*. 1999;27:97–132.
28. National Nosocomial Infections Surveillance System. National nosocomial infections surveillance (NNIS) system report. *Am J Infect Control*. 2004;32:470–485.

APPENDIX A. CPT codes for open and laparoscopic colectomy from NSQIP database

CPT coding for open colectomy	*CPT*
Colectomy, partial; with anastomosis	44140
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 resection, with colostomy or ileostomy and creation of mucofistula	44144
Colectomy, partial; with removal of terminal ileum with ileocolostomy	44160
Mobilization (take-down) of splenic flexure performed in conjunction with partial colectomy	44139
CPT coding for laparoscopic colectomy	*CPT*
Laparoscopy, surgical; colectomy, partial, with anastomosis	44204
Laparoscopy, surgical; colectomy, partial, with removal of terminal ileum with ileocolostomy	44205
Laparoscopy, surgical; colectomy, partial, with end colostomy and closure of distal segment (Hartmann type procedure)	44206
Laparoscopy, surgical; mobilization (take-down) of splenic flexure performed in conjunction with partial colectomy	44213

CPT = Current Procedural Terminology; NSQIP = National Surgical Quality Improvement Program.

APPENDIX B NIS and NSQIP matched comorbidities[5]

Comorbidity	*NIS ICD-9-CM code(s) or variables[a]*	*NSQIP variables*
Anemia	"cm_anemdef" (deficiency anemia); "cm_bldloss" (chronic blood loss anemia)	"prhct" (preoperative hematocrit)
Chronic obstructive pulmonary disease	491.xx (chronic bronchitis); 492.x (emphysema); 496 (chronic airway obstruction)	"hxcpod" (history of severe chronic obstructive pulmonary disease)
Coagulopathy	"cm_coag" (coagulopathy)	"bleeddis" (bleeding disorders)
Diabetes mellitus	"cm_dm" (diabetes, uncomplicated); "cm_dmcx"	"diabetes" (diabetes mellitus with oral agents or insulin)
Hypertension	"cm_htn_c" (hypertension)	"hypermed" (hypertension requiring medication)
Morbid obesity	278.01 (morbid obesity [BMI of ≥40 kg/m^2]); V85.3 (morbid obesity [BMI of ≥40 kg/m^2])	"height" (height); "weight" (weight)
Nonmorbid obesity	278.00 (obesity [BMI of 30 to 39.9 kg/m2]); V85.4 (obesity [BMI of 30 to 39.9 kg/m^2])	"height" (height); "weight" (weight)
Peripheral vascular disease	"cm_perivasc" (peripheral vascular disorder)	"hxpvd" (history of revascularization or gangrene)

ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification; NIS = Nationwide Inpatient Sample; NSQIP = National Surgical Quality Improvement Program.
[a]"x" is a wildcard digit (can be from 0 to 9).

APPENDIX C. NIS and NSQIP matched adverse events[5]

Adverse event	*NIS ICD-9-CM code(s) or variables[a]*	*NSQIP variables*
Acute kidney injury	584.x (acute kidney failure)	"noprenafl" (acute renal failure, postoperative) "nrenainsf" (progressive renal insufficiency, postoperative)
Cardiac arrest	427.5 (cardiac arrest); 427.41 (ventricular fibrillation)	"ncdarrest" (cardiac arrest requiring cardiopulmonary resuscitation, postoperative); "typeintoc" (cardiac arrest requiring cardiopulmonary resuscitation, intraoperative)
Death	"died" (death)	"death" (death)
Deep vein thrombosis	453.2 (venous embolism and thrombosis of the inferior vena cava); 453.3 (venous embolism and thrombosis of the renal vein); 453.4x (acute venous embolism and thrombosis of unspecified deep vessels of lower extremity); 453.82 (acute venous embolism and thrombosis of deep veins of upper extremity); 453.84 (acute venous embolism and thrombosis axillary veins); 453.85 (acute venous embolism and thrombosis of subclavian veins); and 453.86 (acute venous embolism and thrombosis of internal jugular veins)	"nothdvt" (deep vein thrombosis, with or without inflammation, postoperative)
Myocardial infarction	410.xx (acute myocardial infarction)	"ncdmi" (myocardial infarction, postoperative) "typeintoc" (myocardial infarction, intraoperative)

(*Continued*)

APPENDIX C. Continued

Adverse event	*NIS ICD-9-CM code(s) or variables*[a]	*NSQIP variables*
Peripheral nerve injury	953.x (injury to nerve roots and spinal plexus); 954.x (injury to other nerve(s) of trunk, excluding shoulder and pelvic girdles); 955.x (injury to peripheral nerve(s) of shoulder girdle and upper limb); 956.x (injury to peripheral nerve(s) of pelvic girdle and lower limb)	"nneurodef" (peripheral nerve injury, postoperative
Pneumonia	480.x (viral pneumonia); 481 (pneumococcal pneumonia); 482.xx (other bacterial pneumonia);483.x (pneumonia due to other specified organism); 484.x (pneumonia in infectious diseases classified elsewhere); 485 (bronchopneumonia, organism unspecified); 486 (pneumonia, organism unspecified)	"noupneumo" (pneumonia, postoperative)
Pulmonary embolism	415.1 (pulmonary embolism and infarction)	"npulembol" (pulmonary embolism, postoperative
Sepsis	038.xx (septicemia); 112.5 disseminated candidiasis); 785.52 (septic shock); 995.91 (sepsis); 995.92 (severe sepsis)	"nothsysep" (sepsis, postoperative); "nothseshock" (septic shock, postoperative)
Stroke	997.02 (iatrogenic cerebrovascular infarction or hemorrhage); 430 subarachnoid hemorrhage); 431 (intracerebral hemorrhage); 433.01 (occlusion and stenosis of precerebral arteries with cerebral infarction); 433.11 (occlusion and stenosis of carotid artery with cerebral infarction);433.21occlusion and stenosis of vertebral artery with cerebral infarction); 433.31 occlusion and stenosis of multiple and bilateral precerebral arteries with cerebral infarction); 433.81 (occlusion and stenosis of other specified precerebral artery with cerebral infarction); 433.91 (occlusion and stenosis of unspecified precerebral artery with cerebral infarction); 434.01 (cerebral thrombosis with cerebral infarction); 434.11 (cerebral embolism with cerebral infarction); 34.91 (cerebral artery occlusion, unspecified with cerebral infarction)	"ncnscva" (stroke or cerebrovascular accident, postoperative)
Surgical site infection	998.5x (postoperative infection not elsewhere classified); 996.67 (infection and inflammatory reaction due to other internal orthopedic device, implant, or graft)	"nsupinfec" (superficial surgical site infection, postoperative); "nwndinfd" (deep surgical site infection, postoperative); "norgspcssi" (organ or space surgical site infection, postoperative)
Postoperative intubation	96.01 (insertion of nasopharyngeal airway); 96.02 (insertion of oropharyngeal airway); 96.03 (insertion of esophageal obturator airway); 96.04 (insertion of endotracheal tube); 96.05 (other intubation of respiratory tract); 96.7x (other continuous invasive mechanical ventilation)	
Urinary tract infection	599.0 (urinary tract infection)	"nurninfec" (urinary tract infection, postoperative)
Wound disruption	998.3x (disruption of operation wound)	"ndehis" (wound disruption, postoperative)

ICD-9-CM = *International Classification of Diseases, Ninth Revision, Clinical Modification*; NIS = Nationwide Inpatient Sample; NSQIP = National Surgical Quality Improvement Program.
[a]"x" is a wildcard digit (can be from 0 to 9).