Original Investigation

Use of National Burden to Define Operative Emergency General Surgery

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IMPORTANCE Emergency general surgery (EGS) represents 11% of surgical admissions and 50% of surgical mortality in the United States. However, there is currently no established definition of the EGS procedures.

OBJECTIVE To define a set of procedures accounting for at least 80% of the national burden of operative EGS.

DESIGN, SETTING, AND PARTICIPANTS A retrospective review was conducted using data from the 2008-2011 National Inpatient Sample. Adults (age, ≥18 years) with primary EGS diagnoses consistent with the American Association for the Surgery of Trauma definition, admitted urgently or emergently, who underwent an operative procedure within 2 days of admission were included in the analyses. Procedures were ranked to account for national mortality and complication burden. Among ranked procedures, contributions to total EGS frequency, mortality, and hospital costs were assessed. The data query and analysis were performed between November 15, 2015, and February 16, 2016.

MAIN OUTCOMES AND MEASURES Overall procedure frequency, in-hospital mortality, major complications, and inpatient costs calculated per 3-digit *International Classification of Diseases, Ninth Revision, Clinical Modification* procedure codes.

RESULTS The study identified 421 476 patient encounters associated with operative EGS, weighted to represent 2.1 million nationally over the 4-year study period. The overall mortality rate was 1.23% (95% CI, 1.18%-1.28%), the complication rate was 15.0% (95% CI, 14.6%-15.3%), and mean cost per admission was $13 241 (95% CI, $12 957-$13 525). After ranking the 35 procedure groups by contribution to EGS mortality and morbidity burden, a final set of 7 operative EGS procedures were identified, which collectively accounted for 80.0% of procedures, 80.3% of deaths, 78.9% of complications, and 80.2% of inpatient costs nationwide. These 7 procedures included partial colectomy, small-bowel resection, cholecystectomy, operative management of peptic ulcer disease, lysis of peritoneal adhesions, appendectomy, and laparotomy.

CONCLUSIONS AND RELEVANCE Only 7 procedures account for most admissions, deaths, complications, and inpatient costs attributable to the 512 079 EGS procedures performed in the United States each year. National quality benchmarks and cost reduction efforts should focus on these common, complicated, and costly EGS procedures.

Invited Commentary

Supplemental content at jamasurgery.com

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Emergency general surgery (EGS) encompasses the care of the most acutely ill, highest risk, and most costly general surgery patients.[1-5] There are more than 3 million patients admitted to US hospitals each year for EGS diagnoses, more than the sum of all new cancer diagnoses.[1-5] This is a particularly high-risk population of surgery patients—those who undergo an EGS operation are up to 8 times more likely to die postoperatively than are patients undergoing the same procedures electively.[2] In addition, approximately half of all patients undergoing EGS will develop a postoperative complication,[2,4,6] and up to 15% will be readmitted to the hospital within 30 days of their surgery.[3] Despite the inordinate burden of EGS among operative surgical patients, to our knowledge, surgical benchmarks do not exist for EGS procedures.

Earlier efforts to define the scope of EGS have used various data sources: billing data and relative value units[7] from EGS surgeons, *Current Procedural Terminology* codes of acute care surgery fellows,[8] and single-institution assessments.[9] In 2013, the American Association for the Surgery of Trauma (AAST) Committee on Severity Assessment and Patient Outcomes addressed this issue by publishing a landmark list[10] of 621 *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) diagnosis codes.[11] This list was created to include "any patient (inpatient or emergency department) requiring an emergency surgical evaluation (operative or nonoperative) for diseases within the realm of general surgery as defined by the American Board of Surgery."[10(p1092)] A follow-up study proposed 149 *ICD-9-CM* procedure codes that were identified as procedures that would or could treat any of the aforementioned EGS diagnoses.[1,12-15] These lists represent a significant advance toward a unified definition of EGS; however, the wide clinical heterogeneity limits the ability to translate these studies to existing surgical benchmarking efforts.[1,10,12-15]

To build on this broadly inclusive list of diagnoses that encompass operative and nonoperative EGS patients,[1,10,16,17] a more focused, clinically relevant, and nationally representative list of EGS procedures is needed. The goal of the present study was to expand the current diagnosis-based definition of EGS[10]to define a standardized, representative set of procedures that make up the bulk of the national clinical burden of EGS. This set will simplify efforts to establish EGS benchmarks, guide standardized and focused research priorities, and inform quality improvement programs. As such, the aim of the present study was to identify a set of urgent and EGS procedures that account for more than 80% of the national burden of EGS in terms of frequency, morbidity, mortality, and cost.

Key Points

Question What procedures account for most of the emergency general surgery (EGS) burden in the United States?

Findings In this nationally representative observational study representing more than 2 million patient encounters, 80% of all operative volume, complications, death, and costs were attributable to 7 EGS procedures: partial colectomy, small-bowel resection, cholecystectomy, operative management of peptic ulcer disease, lysis of peritoneal adhesions, appendectomy, and laparotomy.

Meaning The 7 procedures identified in this study represent the greatest clinical EGS burden and may serve as the focus of future quality and benchmarking efforts to improve operative EGS care nationwide.

Methods

Analytic Sample

From November 15, 2015, to February 16, 2016, we queried data from the 2008 to 2011 Hospital Cost and Utilization Project's (HCUP)[16] National Inpatient Sample (NIS). The data query was performed The NIS is the largest all-payers claims database that is publicly available in the United States. The NIS sampling framework consists of a 20% sample of hospitals stratified based on geographic region, ownership control, urban or rural location, teaching status, and number of hospital beds. This framework provides a 90% sample of all hospital discharges in the United States and includes patient-level and hospital-level variables, comprising up to 25 diagnosis codes and 15 procedure codes per patient encounter.[11,16] The HCUP-provided discharge weights are provided annually to allow for nationally representative population weighting of discharges. The Partners Human Research Committee, the institutional review board of Partners Healthcare, approved this study.

The analytic data set consisted of all patients 18 years or older who had a principal diagnosis consistent with the AAST EGS definition based on *ICD-9-CM* diagnosis codes[11,18,19] who were admitted urgently or emergently or who were admitted through the emergency department if the admission type was unknown. The sample was further limited to include only patients who underwent an operative procedure on the day of or the day following admission. To focus the analysis on the scope of practice common to emergency general surgeons across a variety of facility types, patients who underwent primarily obstetric, cardiac, vascular, endovascular, or endoscopic procedures were excluded. Finally, patients undergoing very rare procedures were excluded by removing the bottom 5% of the sample when ranked by procedure frequency.

Variables

Patient- and facility-level demographic data were derived from NIS-provided variables and included age, sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other, and missing), patient zip code income quartile, insurance payer (private, public, uninsured, and other), US census region (Northeast, Midwest, South, and West), hospital teaching status and location (urban teaching, urban nonteaching, and rural), and hospital bed size (small, medium, and large; actual cutoffs vary according to urban or rural location and US census region).

The NIS-provided *ICD-9-CM* procedure codes were analyzed in their original 4-digit format (NN.nx) as well as collapsed into 3-digit procedure groups (NN.n). This was done to ensure that similar procedures were clustered together according to the preexisting *ICD-9-CM* hierarchy of procedure

codes and to avoid underestimation or overestimation of procedural burden owing to an increased or decreased number of second-order divisions. For example, a right-sided hemicolectomy (45.73), a left-sided hemicolectomy (45.75), and a sigmoid hemicolectomy (45.76) would all be considered partial colectomies (45.7x). However, these would remain a distinct procedure group from all variants of total colectomies (45.8x).

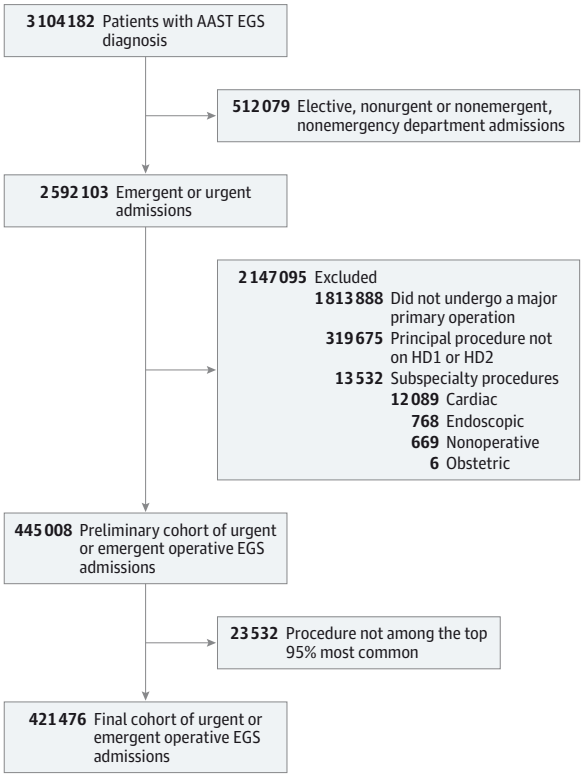
Procedure and procedure group counts were based on the NIS-provided principal procedure code. Mortality rates were also based on NIS-provided outcome data. Complications were based on secondary *ICD-9-CM* codes and included 13 complication types: pneumonia, deep vein thrombosis and/or pulmonary embolism, acute renal injury, stroke, myocardial infarction, cardiac arrest, acute respiratory distress syndrome, sepsis, septic shock, mechanical wound failure, wound infection, postoperative gastrointestinal tract complications, and other or unspecified postoperative complications including retained foreign body and postoperative hemorrhage.[17,20] Each patient could theoretically have 1 to 13 complications during an inpatient stay. Complication rate was calculated as a binary variable, indicating the presence of any complication, whereas the total complication count was calculated as the sum of all complications by procedure group. The NIS-provided inpatient hospital charges were converted to estimated costs using HCUP-provided cost to charge ratios, and these estimates from 2008 to 2011 were normalized to 2015 US dollars using annual hospital consumer-price indices.[1,10,18,19,21]

Statistical Analysis

Procedure count, total deaths, total complications, and total index hospitalization costs were calculated for each 3-digit *ICD-9-CM* procedure group included in the final analytic data set. A mortality score and a complications score were defined as the product of procedure frequency and mortality rate or complications rate, respectively. Scores were calculated per procedure groups and then ranked, such that each 3-digit *ICD-9-CM* procedure group received 1 mortality rank and 1 complication rank. These 2 ranks were then summed to generate a final burden rank by procedure group.

Once sorted by burden rank, the cumulative attributable burden was determined regarding the frequency, total deaths, total complications, and total hospital costs. For procedure groups ranked 1 to 35, the cumulative attributable burden of procedure frequency, for example, was calculated as the sum of the number of procedures ranked 1 to *n* divided by the total number of procedures in the entire analytic sample. This measure is akin to a percentile value for each ranked procedure. The cumulative attributable burden for frequency, deaths, complications, and costs was then calculated. For the procedure group with rank *x*, the cumulative attributable burden for an outcome of interest represents the summation of the proportion of total burden for that outcome attributable to procedures ranked 1 through *x*. A threshold of 80% of the total population burden was established as an a priori cutoff to represent significant representation of population-level burden for each of the 4 outcomes of interest. Costs were not used to calculate burden scores, but they were reported as an outcome measure to determine whether highly ranked procedures also account for significant surgical health care spending. All counts and means were weighted using NIS-provided population design-weights generalized with Stata's svy command to account for patient clustering within hospitals and to attain nationally weighted estimates. All analyses were completed using Stata, version 13.0 (StataCorp, Inc). Data analysis was conducted from November 15, 2015, to February 16, 2016.

Figure 1. Creation of Operative Emergency General Surgery Cohort

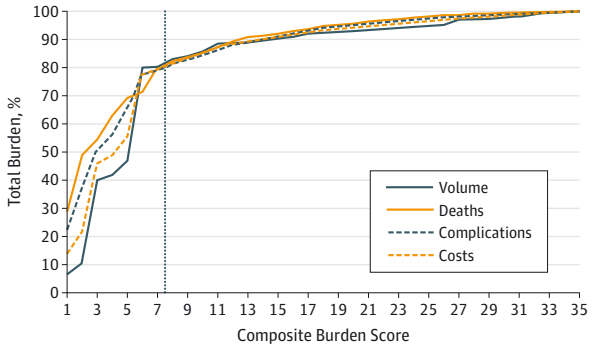


Data were obtained from the National Inpatient Sample for admissions between 2008 and 2011.[16] AAST indicates American Association for the Surgery of Trauma; EGS, emergency general surgery; and HD, hospital day.

Results

This study identified a sample of more than 3.1 million patients with an EGS diagnosis (**Figure 1**) weighted to represent more than 35.1 million patient encounters nationally in 4 years. From this sample, 512 079 patients (16.5%) were excluded because they were not admitted urgently or emergently. An additional 1 813 888 patients (58.4%) were excluded because they did not undergo a major operation during their hospital stay. Another 319 675 individuals (10.3%) were excluded because they did not undergo an operative procedure on the first or second day of admission. After excluding a small proportion of cardiac, vascular, obstetric, endoscopic, nonoperative procedure codes (13 532 [0.4%]), as well as rare procedure codes (23 532 [0.8%]), the final analytic sample included 421 476 patient encounters (13.6% of the original sample). This representative cohort exhibits appropriate patient-level, facility-

Figure 2. Cumulative National Burden of Emergency General Surgery Procedures, by Rank



Each line represents the proportion of cumulative national burden of procedure volume, patient deaths, complications, and costs. The vertical dotted line delineates the top 7 ranked procedures, which accounted for approximately 80% of all cumulative burden. Data were obtained from the National Inpatient Sample for admissions between 2008 and 2011.[16]

level, and geographic diversity (eTable 1 in the Supplement). This sample included adults of all ages (range, 18-105 years), was racially/ethnically diverse (61.3% non-Hispanic white, 9.0% non-Hispanic black, and 14.5% Hispanic individuals), comprised a diverse payer mix (46.1% private, 37.8% public, and 11.6% uninsured), and had even distribution across all income quartiles (range, 24.6% in quartile 1 to 25.4% in quartile 3). This sample also represented a diverse array of facilities in which 61.2% were large hospitals and 11.8% were urban teaching hospitals. Applying NIS-provided population weights, the final analytic sample represented a total of 2.1 million operative patient encounters nationwide within 4 years, ranging from 502 484 (95% CI, 453 226-551 742) in 2008 to 537 031 (95% CI, 484 819-589 243) in 2009. The mean mortality in the overall sample was 1.23% (95% CI, 1.18%-1.28%), and 15.0% (95% CI, 14.6%-15.3%) of the patients experienced 1 or more complication. The mean estimated inpatient hospital cost per admission was $13 241 (95% CI, $12 957-$13 525). Nationally, the annual estimated cost ranged from $6.1 billion (95% CI, $5.5 billion to $6.7 billion) in 2008 to $6.6 billion (95% CI, $6.0 billion to $7.3 billion) in 2010.

The final analytic sample included 137 unique 4-digit *ICD-9-CM* procedure codes, which mapped into 35 distinct 3-digit procedure group codes. When ordered by burden rank 1 to 35, the cumulative attributable burden for total procedure count, total deaths, total complications, and total costs increased sharply through procedures ranked 1 to 7, but all 4 curves notably flattened thereafter (**Figure 2**). Each additional procedure increased the cumulative burden (for any of the 4 outcomes) by a mean of 9% to 12% for the first 7 procedures, whereas the next 7 procedures increased the cumulative attributable burden by a mean of 2% with each additional procedure. These first 7 procedure groups accounted for 80.0% of all procedures, 80.3% of all deaths, 78.9% of all complications, and 80.2% of all inpatient costs in this nationally representative data set (Figure 2). The top 7 procedures included partial colectomy (*ICD-9-CM* procedure group 45.7x), small-bowel resection (group 45.6x), cholecystectomy (group 51.2x), operative management of peptic ulcer disease (group 44.4x), lysis of peritoneal adhesions (group 54.5x), appendectomy (group 47.0x), and laparotomy (group 54.1x) (**Table 1**). The top 10 primary diagnosis codes associated with each of these top-ranked procedures as well as the most common diagnoses associated with procedure group 54.1x (laparotomy) are presented in eTable 2 and eTable 3, respectively, in the Supplement.

Table 1. Top 7 Procedure Groups by Burden Rank[a]

Procedure Group/ *ICD-9-CM* Code	Description	Count[b]
45.7x	Open and other partial excision of large intestine	138 992
45.76	Open and other sigmoidectomy	51 733
45.73	Open and other right hemicolectomy	48 119
45.75	Open and other left hemicolectomy	16 332
45.72	Open and other cecectomy	11 675
45.79	Other and unspecified partial excision of large intestine	6088
45.74	Open and other resection of transverse colon	4295
45.71	Open and other multiple segmental resection of large intestine	751
45.6x	Other excision of small intestine	78 478
45.62	Other partial resection of small intestine	75 520
45.61	Multiple segmental resection of small intestine	2653
45.63	Total removal of small intestine	306
51.2x	Cholecystectomy	619 197
51.23	Laparoscopic cholecystectomy	565 388
51.22	Cholecystectomy	52 322
51.21	Other partial cholecystectomy	743
51.24	Laparoscopic partial cholecystectomy	681
44.4x	Control of hemorrhage and suture of ulcer of stomach or duodenum	31 571
44.42	Suture of duodenal ulcer site	19 359
44.41	Suture of gastric ulcer site	12 019
44.40	Suture of peptic ulcer, not otherwise specified	170
44.49	Other control of hemorrhage of stomach or duodenum	19
54.5x	Lysis of peritoneal adhesions	102 856
54.59	Other lysis of peritoneal adhesions	70 847
54.51	Laparoscopic lysis of peritoneal adhesions	32 009
47.0x	Appendectomy	682 043
47.01	Laparoscopic appendectomy	518 421
47.09	Other appendectomy	163 622
54.1x	Laparotomy	9418
54.11	Exploratory laparotomy	6642
54.19	Other laparotomy	2509
54.12	Reopening of recent laparotomy site	267

Abbreviation: *ICD-9-CM*, *International Classification of Diseases, Ninth Revision, Clinical Modification*.

[a] Data were obtained from the National Inpatient Sample, 2008-2011.[16]

[b] Counts were weighted to represent the entire US population over the 4-year study period.

A complete list of procedure frequency, mortality rate, complication rate, burden ranks, and mean inpatient costs of all 35 procedure groups is reported in **Table 2**. Among the top

Table 2. All Procedure Groups by Burden Rank[a]

Burden Rank	Procedure Group	Description	Procedure Count, 2008-2011[b]	Rate, %		Mean Cost, $	Rank		Combined Burden Score
				Mortality	Complication		Mortality	Morbidity	
1	45.7x	Open and other partial excision of large intestine	138 992	5.33	42.80	27 558.77	1	1	2
2	45.6x	Other excision of small intestine	78 478	6.47	46.94	28 450.72	2	4	6
3	51.2x	Cholecystectomy	619 197	0.22	8.06	10 579.35	6	2	8
4	44.4x	Control of hemorrhage and suture of ulcer of stomach or duodenum	31 571	6.83	42.00	27 095.60	4	6	10
5	54.5x	Lysis of peritoneal adhesions	102 856	1.59	28.09	17 387.27	5	5	10
6	47.0x	Appendectomy	682 043	0.08	7.27	9664.30	8	3	11
7	54.1x	Laparotomy	9418	23.76	40.15	21 962.55	3	12	15
8	86.2x	Excision or destruction of lesion or tissue of skin and subcutaneous tissue	60 709	0.73	12.13	11 555.28	10	8	18
9	46.7x	Other repair of intestine	12 297	4.08	39.83	25 539.82	9	10	19
10	53.0x	Other unilateral repair of inguinal hernia	45 483	0.83	12.22	9277.21	11	9	20
11	53.6x	Repair of other hernia of anterior abdominal wall with mesh	53 493	0.48	16.23	12 823.98	14	7	21
12	45.8x	Total intra-abdominal colectomy	4301	16.55	69.20	43 083.98	7	16	23
13	44.6x	Other repair of stomach	6993	4.45	32.48	23 584.38	12	17	29
14	53.5x	Repair of other hernia of anterior abdominal wall (with or without mesh)	18 843	1.08	19.44	12 186.98	16	13	29
15	17.3x	Laparoscopic partial excision of large intestine	18 526	0.75	21.34	19 283.42	20	11	31
16	46.0x	Exteriorization of intestine	6084	4.54	34.39	23 605.71	13	18	31
17	53.4x	Repair of umbilical hernia	25 714	0.66	12.42	9898.13	18	14	32
18	46.1x	Colostomy	4290	5.85	39.67	25 564.52	15	22	37
19	46.8x	Dilation and manipulation of intestine	5923	2.69	33.22	18 823.93	19	19	38
20	34.5x	Pleurectomy	4682	1.40	65.90	29 078.10	27	15	42
21	83.4x	Other excision of muscle, tendon, and fascia	8627	2.22	15.99	15 596.08	17	26	43
22	53.7x	Repair of diaphragmatic hernia, abdominal approach	5534	2.23	34.68	25 254.31	23	21	44
23	83.3x	Excision of lesion of muscle, tendon, fascia, and bursa	10 076	1.21	15.15	14 366.47	24	24	48
24	48.6x	Other resection of rectum	5817	1.83	26.76	22 344.31	25	23	48
25	84.1x	Amputation of lower limb	4484	3.01	24.61	18 092.50	21	28	49
26	53.2x	Unilateral repair of femoral hernia	7969	1.33	18.99	10 884.23	26	25	51
27	48.8x	Incision or excision of perirectal tissue or lesion	39 145	0.07	4.97	7107.20	34	20	54
28	46.5x	Closure of intestinal stoma	6014	0.76	20.62	14 492.26	29	27	56
29	54.2x	Diagnostic procedures of abdominal region	5819	2.28	13.42	12 020.49	22	33	55
30	83.0x	Incision of muscle, tendon, fascia, and bursa	10 220	0.49	9.72	11 091.39	28	29	57
31	53.9x	Other hernia repair	5342	0.67	15.55	12 351.34	31	31	62
32	49.0x	Incision or excision of perianal tissue	17 202	0.15	5.67	7140.66	33	30	63
33	49.4x	Procedures on hemorrhoids	9064	0.47	5.73	6738.33	30	35	65
34	54.0x	Incision of abdominal wall	5160	0.58	12.00	10 313.80	32	34	66
35	27.0x	Drainage of face and floor of mouth	8179	0.13	9.82	9122.96	35	32	67

[a] Data were obtained from the National Inpatient Sample, 2008-2011.[16]

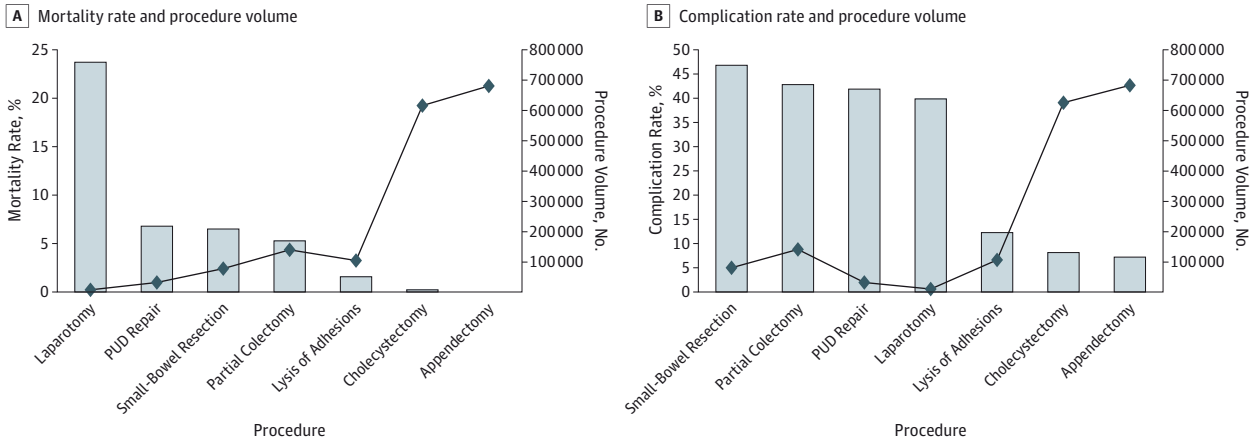
[b] Counts were weighted to represent the entire US population over the 4-year study period.

7 ranked procedures, the frequency varied from 682 043 primary appendectomies to 9418 primary laparotomies, the mortality rate ranged from 0.08% for appendectomy to 23.76% for laparotomy, and the complication rate ranged from 7.27% for appendectomy to 46.94% for small-bowel resection. Finally, mean inpatient costs ranged from $9664.30 for appendectomy to $28 450.72 for small-bowel resection. **Figure 3** shows the associations between frequency and mortality rate as well as between frequency and complication rate for these 7 procedure groups.

Discussion

To our knowledge, this study is the first to use a nationally representative sample to identify the EGS procedures that account for the greatest number of cases, deaths, complications, and inpatient costs. Starting with a previously defined list of 621 diagnoses, this study has identified 7 procedure groups that account for approximately 80% of the burden of operative EGS throughout the United States. This focused and clinically relevant list of

Figure 3. Comparison of Mortality and Complication Rates With Procedure Volume



Association between mortality (A) and complication (B) rates and the volume of procedures. Data were obtained from the National Inpatient Sample for admissions between 2008 and 2011.[16] PUD indicates peptic ulcer disease.

procedures is an appropriate starting point for efforts of surgeons and researchers to improve quality, reduce costs, and develop national benchmarks for EGS.

To our knowledge, this list is the first to be derived from a nationally representative data set that includes patients of all ages, races/ethnicities, income levels, facility types, and geographic regions. In addition, ranking by the cross-products of both frequency × mortality rate and frequency × complication rate enabled identification of procedures that are common, deadly, and represent significant morbidity (Figure 2). By excluding procedures that are not common to the scope of practice of all general surgeons in the United States (ie, cardiac, thoracic, vascular, obstetric, and endoscopic), the resultant list represents sufficient homogeneity that can be interpreted in a clinically meaningful way throughout the country. Although cost was not used to rank the procedures, it is notable that the same 7 procedures ranked by clinical burden also accounted for 80% of all EGS-related inpatient costs (Figure 2). This finding further emphasizes the usefulness of these 7 procedures to serve as the basis for understanding ways to improve quality and reduce cost among patients undergoing EGS.

These findings build on important prior work seeking to define EGS.[1,10,21] The diagnosis codes put forth by the AAST's 2013 committee[10] are broadly inclusive of all operative and nonoperative diagnoses that may require urgent care provided by a surgeon. However, these analyses demonstrate that less than 14% of all inpatients with one of these diagnoses required a major operation within 2 days of an emergent or urgent admission. Ogola and Shafi[21] subsequently identified 9 diagnoses that constituted 80% of all admissions; however, these diagnoses were not limited to operative admissions. Although a significant proportion of surgical care is nonoperative, many patients throughout the United States who are admitted for diagnoses such as diverticulitis, bowel obstruction, or soft-tissue infections are never evaluated or treated by a surgeon. As such, basing quality benchmarks on such an inclusive list may not provide specific information on the quality of surgical care.

In 2014, Gale and colleagues[1] proposed a list of 149 procedures that could be used to categorize patients with any of the AAST-defined EGS diagnoses. However, this list does not take into account which of these procedures represent the most significant proportion of national burden. In addition, the list's broad clinical heterogeneity may make derivation of surgical national quality targets and national benchmarks difficult. Thus, although existing work has done much to establish a novel, sensitive, and inclusive definition of EGS, a focused sample that represents the true national burden is needed to focus benchmarking, quality improvement, and cost reduction efforts.

Existing quality efforts in health care focus on the conditions that represent common reasons for admissions nationwide and account for significant morbidity, mortality, and costs.[12] For example, the 2012 Centers for Medicare & Medicaid Services' Readmission Reduction Program was applied only to patients admitted for acute myocardial infarction, heart failure, and pneumonia.[12] When this program was expanded to surgical patients, it likewise was limited to 3 procedures: total hip arthroplasty, total knee arthroplasty, and coronary artery bypass graft.[12,13] Focusing on a subset of important procedures is in keeping with the Centers for Medicare & Medicaid–sponsored Surgical Care Improvement Project,[13] the American College of Surgeons' National Surgical Quality Improvement Program,[5,14] and the Society of Thoracic Surgeons'[15] quality benchmarks, which are all focused on patients who have undergone one of a specific, clearly defined set of procedures. Such measures are thought to be valuable because they are indicative of care provided by surgeons and because they can be applied to a variety of hospitals throughout the United States. Given their high prevalence nationally and the high proportion of burden that they represent, deriving EGS benchmarks from the 7 procedures identified in this study could lead to better clinical decision making, patient outcomes, and cost savings.

The findings presented should be interpreted in light of the study's limitations. First, these results were derived from claims data rather than from prospective, clinically derived databases.

However, the national representativeness of the NIS facilitates the identification of the highest burden procedures throughout the United States. Future studies are warranted to subsequently monitor these procedures in prospective clinical-derived databases. Second, the exclusion of nonoperative patients from the final analytic data set omits an important cohort that may not require an operative intervention but may otherwise require the care of a surgeon. As discussed above, the list provided in this study is meant to guide benchmarks for operative EGS akin to those that exist for nonemergent surgery. Analysis of nonoperative care is warranted and important, although many databases preclude the ability to determine which patients receive care that is managed primarily by surgeons and which receive care that is managed primarily by nonsurgeons, which may result in differences in both quality and costs of care.[22] Third, this analysis was intentionally limited to operative procedures performed within 2 days of admission for an EGS-related diagnosis. As such, it does not account for the burden of trauma-related procedures or semi-elective procedures that take place many days after admission. Finally, these findings do not represent other forms of burden, such as postoperative quality of life, return to work, or other patient-centered outcomes. This limitation is common in studies using claims databases and warrants further prospective inquiry to identify the outcomes that matter most to patients undergoing EGS procedures.

Conclusions

Analysis of the largest available nationally representative database demonstrates that more than half of a million patients undergo urgent or emergent general surgery operations annually in the United States that account for more than $6 billion in annual costs. Only 7 representative procedures account for approximately 80% of all admissions, deaths, complications, and inpatient costs attributable to operative EGS nationwide. National quality benchmarks and cost reduction efforts should focus on these common, complicated, and costly EGS procedures.

ARTICLE INFORMATION

Correction: This article was corrected on June 15, 2016, to fix an incorrect burden rank description in Table 2.

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Study concept and design: Scott, Olufajo, Rose, Zogg, Haider, Salim, Havens.
Acquisition, analysis, or interpretation of data: Scott, Olufajo, Brat, Rose, Zogg, Haider, Havens.
Drafting of the manuscript: Scott, Olufajo, Brat, Havens.
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Administrative, technical, or material support: Scott, Rose, Zogg, Haider.
Study supervision: Brat, Rose, Haider, Salim, Havens.

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REFERENCES

1. Gale SC, Shafi S, Dombrovskiy VY, Arumugam D, Crystal JS. The public health burden of emergency general surgery in the United States: a 10-year analysis of the Nationwide Inpatient Sample—2001 to 2010. *J Trauma Acute Care Surg*. 2014;77(2):202-208.

2. Havens JM, Peetz AB, Do WS, et al. The excess morbidity and mortality of emergency general surgery. *J Trauma Acute Care Surg*. 2015;78(2):306-311.

3. Havens JM, Olufajo OA, Cooper ZR, Haider AH, Shah AA, Salim A. Defining rates and risk factors for readmissions following emergency general surgery [published online November 11, 2015]. *JAMA Surg*. doi:10.1001/jamasurg.2015.4056.

4. Patel SS, Patel MS, Goldfarb M, et al. Elective vs emergency surgery for ulcerative colitis: a National Surgical Quality Improvement Program analysis. *Am J Surg*. 2013;205(3):333-337.

5. Kassin MT, Owen RM, Perez SD, et al. Risk factors for 30-day hospital readmission among general surgery patients. *J Am Coll Surg*. 2012;215(3):322-330.

6. Kwan TL, Lai F, Lam CM, et al. Population-based information on emergency colorectal surgery and evaluation on effect of operative volume on mortality. *World J Surg*. 2008;32(9):2077-2082.

7. Galante JM, Phan HH, Wisner DH. Trauma surgery to acute care surgery: defining the paradigm shift. *J Trauma*. 2010;68(5):1024-1031.

8. Dente CJ, Duane TM, Jurkovich GJ, Britt LD, Meredith JW, Fildes JJ. How much and what type: analysis of the first year of the acute care surgery operative case log. *J Trauma Acute Care Surg*. 2014;76(2):329-338.

9. Becher RD, Meredith JW, Chang MC, Hoth JJ, Beard HR, Miller PR. Creation and implementation of an emergency general surgery registry modeled after the National Trauma Data Bank. *J Am Coll Surg*. 2012;214(2):156-163.

10. Shafi S, Aboutanos MB, Agarwal S Jr, et al; AAST Committee on Severity Assessment and Patient Outcomes. Emergency general surgery: definition and estimated burden of disease. *J Trauma Acute Care Surg*. 2013;74(4):1092-1097.

11. *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)*. http://www.cdc.gov/nchs/icd/icd9cm.htm. Updated June 13, 2013. Accessed December 15, 2015.

12. Centers for Medicare and Medicaid—Readmissions Reduction Program. https://www.cms.gov/medicare/medicare-fee-for-service-payment/acuteinpatientpps/readmissions-reduction-program.html. Updated February 4, 2016. Accessed December 15, 2015.

13. The Joint Commission. Surgical Care Improvement Project. http://www.jointcommission.org/surgical_care_improvement_project/. Updated March 20, 2016. Accessed December 15, 2015.

14. American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP). https://www.facs.org/quality-programs/acs-nsqip. Updated 2016. Accessed December 15, 2015.

15. The Society of Thoracic Surgeons—STS National Database. http://www.sts.org/national-database. Updated 2016. Accessed December 15, 2015.

16. Hospital Cost and Utilization Project. Overview of the National (Nationwide) Inpatient Sample (NIS). http://www.hcup-us.ahrq.gov/nisoverview.jsp. Updated February 2016. Accessed December 15, 2015.

17. Shah AA, Haider AH, Zogg CK, et al. National estimates of predictors of outcomes for emergency general surgery. *J Trauma Acute Care Surg*. 2015;78(3):482-491.

18. Federal Reserve Bank of St Louis. Consumer price index for all urban consumers: hospital and related services. https://research.stlouisfed.org/fred2/series/CUSR0000SEMD/. Updated March 16, 2016. Accessed December 15, 2015.

19. US Department of Labor. Bureau of Labor Statistics. Consumer Price Index. http://www.bls.gov/cpi/. Updated February 19, 2016. Accessed December 15, 2015.

20. Zogg CK, Najjar P, Diaz AJ, et al. Rethinking priorities: cost of complications after elective colectomy [published online October 31, 2015]. *Ann Surg*.

21. Ogola GO, Shafi S. Cost of specific emergency general surgery diseases and factors associated with high-cost patients. *J Trauma Acute Care Surg*. 2016;80(2):265-271.

22. Bilderback PA, Massman JD III, Smith RK, La Selva D, Helton WS. Small bowel obstruction is a surgical disease: patients with adhesive small bowel obstruction requiring operation have more cost-effective care when admitted to a surgical service. *J Am Coll Surg*. 2015;221(1):7-13.