Trauma Surgery & Acute Care Open

Identifying those at risk: predicting patient factors associated with worse EGS outcomes

Komal Abdul Rahim ,[1,2] Namra Qadeer Shaikh,[2] Maryam Pyar Ali Lakhdir,[3] Asma Altaf Hussain Merchant ,[4] Noreen Afzal,[5] Saad Bin Zafar Mahmood,[6] Saqib Kamran Bakhshi,[7] Mushyada Ali,[8] Zainab Samad,[8] Adil H Haider[9]

[1]Centre of Excellence in Trauma and Emergencies, The Aga Khan University, Karachi, Sindh, Pakistan
[2]Dean's Office, Medical College, The Aga Khan University, Karachi, Sindh, Pakistan
[3]Community Health Sciences, The Aga Khan University, Karachi, Sindh, Pakistan
[4]Medical College, The Aga Khan University, Karachi, Pakistan
[5]Department of Surgery, The Aga Khan University, Karachi, Sindh, Pakistan
[6]Department of Medicine, The Aga Khan University Medical College Pakistan, Karachi, Sindh, Pakistan
[7]Department of Neurosurgery, The Aga Khan University, Karachi, Sindh, Pakistan
[8]Department of Medicine, The Aga Khan University, Karachi, Sindh, Pakistan
[9]Dean of Medical College and Professor of Surgery, The Aga Khan University, Karachi, Sindh, Pakistan

Correspondence to
Dr Komal Abdul Rahim; komal.rahim@aku.edu

This work has been presented in the American Surgical Congress (ASC) 2023.

Received 11 November 2024
Accepted 6 May 2025

To cite: Abdul Rahim K, Shaikh NQ, Lakhdir MPA, *et al*. *Trauma Surg Acute Care Open* 2025;**10**:e001690.

ABSTRACT

Background Comorbidity has a detrimental impact on Emergency General Surgery (EGS) outcomes. In lesser-developed countries with inconsistent documentation of comorbid conditions, undiagnosed and progressively worsening comorbidities can worsen EGS outcomes. We aimed to discern the comorbidity index as a predictor of complications and inpatient mortality in EGS using a large South Asian sample population.

Materials and methods Data of adult patients with AAST-defined EGS diagnoses at primary index admission from 2010 to 2019 were retrieved. Patients were categorized into predefined EGS groups using ICD-9 CM codes. Primary exposure was comorbidity using the Charlson Comorbidity Index (CCI). The primary outcome was inpatient mortality, and the secondary outcome was complication status. Multiple logistic and Cox regression with Weibull distribution was performed.

Results Analysis of 32 280 patients showed a mean age of 40.06±16.87 years. Overall comorbidity, inpatient mortality, and complication rates were 44.6%, 2.42% and 36.37%, respectively. Patients with moderate CCI had the highest complications (AOR 6.61, 95% CI 5.91, 7.37), and severe comorbidity had the highest hazards (AOR 3.79, 95% CI 2.89, 4.98). Male gender, increasing age, emergent admission status, and lack of insurance were associated with moderate and severe CCI, resulting in prolonged length of stay (5.72 and 5.83 days), reduced survival time (20.04 and 21.95 days), and higher mortality rates (10.52% and 9.48%).

Conclusions We identified predictive patient-level factors associated with higher CCI and worse EGS outcomes. Our findings can help stratify population subsets at risk of worse outcomes, provide valuable insight into disease progression, and aid decision-making in EGS patients.

Level of Evidence III

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Patients with pre-existing conditions tend to have worse hospital outcomes in Emergency General Surgery (EGS) patients.

WHAT THIS STUDY ADDS

⇒ Due to the paucity of literature from low-income and middle-income countries, the severity of comorbidities and their effect on EGS outcomes are poorly understood.
⇒ Our findings show that patients with severe Charlson Comorbidity Index (CCI) had the highest hazards of mortality, while patients with moderate CCI had higher odds of developing complications.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our study findings make the case for risk-stratifying the patients based on their comorbidity severity to improve EGS outcomes.
⇒ Attention from clinicians is required to aid the decision-making of EGS patients.

INTRODUCTION

Acute care surgery (ACS) conditions present a high-risk subset of patients associated with increased morbidity and mortality. Now defined as an independent component of ACS, Emergency General Surgery (EGS) conditions require acute management of complex surgical conditions. This necessitates sound and swift decision-making while ensuring individually tailored care to a wide array of patients.[1] While timely access to care is of utmost importance in such acute care conditions, other patient-level factors and comorbid conditions have also been shown to influence outcomes in EGS directly.[1 2] Hence, it is essential to ensure that access to surgical care is in adjunct with perioperative optimization of the underlying medical conditions, which are integral to improving postoperative outcomes.[3]

Various underlying secondary medical conditions directly influence disease complexity across the spectrum of health conditions. Due to higher complication rates and mortality from comorbid conditions in ACS, prognostication of outcomes mandates the need for accurate risk stratification before surgery.[4] Among the various tools developed, the Charlson Comorbidity Index (CCI) leverages specific comorbid medical conditions, ranking risk groups through severity scores attributed to specific illnesses[5] to predict their cumulative risk of 1 year mortality.[6]

The CCI has been extensively validated for use in various medical and surgical conditions, with higher CCI scores associated with increased risk of adverse outcomes, including complication rates, length of stay, and mortality.[7] Recent efforts toward benchmarking in ACS have also validated the use of CCI as a risk prediction tool in the context of emergency general surgery[1] in developed countries. However, complication rates and outcomes of EGS remain non-uniform globally, owing to unique racial, geographical, and sociodemographic influences on human physiology. Patterns of frequency and severity of comorbidities and their impact on disease prognosis vary across populations and patient profiles. As such, the utility of tools leveraging patient-level factors for outcome assessment can vary across societies, influenced by their unique sociodemographic case mix.

In lesser-developed countries, healthcare systems largely depend on out-of-pocket payments, despite most of their populations falling below the poverty line.[8] Such costs add to the financial constraints that are a significant barrier to timely healthcare access. Subsequent poor follow-up rates with healthcare providers lead to increased progression and severity of comorbid conditions.[9–11] This is further aggravated by a lack of centralized patient databases and inconsistent documentation of comorbid conditions, making risk stratification difficult in time-sensitive, acute care settings.[12 13] While the negative impact of comorbidity on EGS conditions is already well known, undiagnosed and progressively worsening comorbidities in such populations can have an even worse effect on disease course and outcomes. Understanding profiles of patients and population subsets at high risk of severe comorbidity (high CCI scores) and complications from EGS can aid in decision-making and outcome prognostication. Hence, the objective of this study is to discern the comorbidity index as a predictor of inpatient mortality and major complications in EGS using a large South Asian sample population.

METHODS

Patient population and data source

A secondary analysis was conducted using Electronic Medical Records (EMRs) data from a large urban tertiary care hospital in South Asia. Patient entries from the institutional administrative database were retrieved for primary index admissions with an American Association for Surgery and Trauma (AAST) defined EGS diagnosis[14] from 2010 to 2019. Patients were identified and categorized into predefined EGS groups using the International Classification of Diseases-9th Rev.-Clinical Modification (ICD-9-CM) codes corresponding to primary and secondary EGS conditions outlined by the AAST. This yielded data on 80 704 patients admitted over a decade. A schematic diagram of the number of records analyzed is presented in figure 1. The patients included were admitted from the emergency department and consultant clinics with a primary EGS diagnosis at index admission. Thereby, a cohort of 32 280 patient records was identified. These included all adult patients admitted to our center without racial, ethnic, or gender restrictions.

Variables and code groups

To ensure the absence of redundancy and duplicate entries, patients admitted through hospital-associated secondary facilities, outside referral centers, community health centers, departments other than the ED or CC, and repeat admissions were excluded. The final patient cohort included those admitted with unique ICD-9-CM codes corresponding to the following EGS conditions at primary index hospital admissions[4 15]:

1. **General abdominal conditions**: abdominal pain, abdominal hernia, peritonitis and intestinal abscess, cancer of gastrointestinal (GI) organs and peritoneum, gastrointestinal hemorrhage.
2. **Intestinal obstruction**: intestinal obstruction without hernia, cancer of the colon, rectum, and anus.
3. **Upper gastrointestinal tract**: appendicitis and other appendiceal conditions, gastritis and duodenitis, gastroduodenal ulcer (except hemorrhage), intestinal infections, other disorders of the stomach and duodenum.
4. **Hepatic–pancreatic–biliary conditions**: biliary tract disease, pancreatic disorders (not diabetes)
5. **Lower gastrointestinal tract**: anal and rectal conditions, diverticulosis and diverticulitis, hemorrhoids, regional enteritis, and ulcerative colitis.
6. **Cardiothoracic conditions**: aortic and peripheral arterial embolism; aortic, peripheral, and visceral arterial disease, esophageal disorders, pericarditis, endocarditis and myocarditis, pleurisy, pneumothorax, pulmonary collapse.

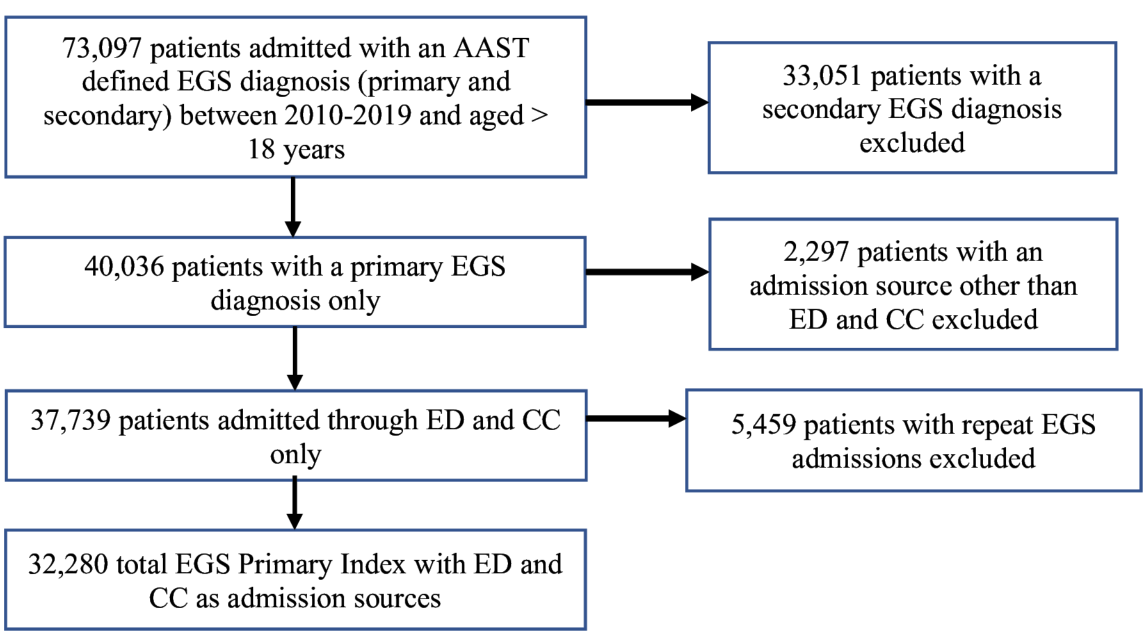

Figure 1 Schematic inclusion and exclusion criteria. AAST, American Association for Surgery and Trauma; CC, consulting clinic; EGS, emergency general surgery; ED, emergency department.

7. **Vascular**: peripheral and visceral atherosclerosis, phlebitis, thrombophlebitis, and thrombosis
8. **Skin conditions and soft tissues**: chronic ulcer of skin, skin and subcutaneous tissue infections, gangrene
9. **Resuscitation:** acute respiratory failure, shock.
10. **Others**: neoplasms of unspecified nature, other connective tissue diseases, other diseases of bladder and urethra, complication of device; implant or graft, complications of surgical procedures and aftercare.

The hospital database provided information on patient demographics (age, sex, insurance status, area of residence), ICD-9-CM diagnostic codes, procedure codes, and length of stay. Additional information that was retrieved or otherwise calculated included patient-level characteristics: admission status (elective and emergent admission), comorbidities (as identified in the CCI), complications, and discharge disposition (expired, sent home, left against medical advice, transferred due to personal reasons, and transferred to a healthcare facility).

Comorbid conditions (primary exposure) included in CCI were coded and stratified based on the severity of underlying conditions, with a score of 0 corresponding to none, a score of 1–2 corresponding to mild, a score of 3–4 corresponding to moderate, and a score of 5 and above corresponding to severe CCI. A major complication included myocardial infarction, cerebrovascular accident/stroke, deep vein thrombosis/pulmonary embolism/thrombophlebitis, acute renal failure, pneumonia, pulmonary failure, urinary tract infection, sepsis, septic shock, pseudomembranous colitis, peripheral nerve injury, coma, and hemorrhage.

To ensure robust analysis, the age of the participants was broadly classified into three categories: 18–40 years, 41–60 years, and >61 years. The patients' sex was categorized into male and female. Since the databases lacked documentative indicators for the patient's financial status, the ability to pay was used as a proxy and was categorized as insured and uninsured payer status (self-paid). Similarly, admission source and status were used as a proxy for disease severity and were stratified based on elective and emergent admissions. For stratification purposes, the area of residence was categorized as within and outside the city. Overall comorbidity, complication status, and rates were also calculated. The primary outcome of the study was inpatient mortality, defined as the death of the patient during their hospital length of stay (LOS); death occurring after the hospital discharge was not captured. The secondary outcome was complication status (details on complications are mentioned in the above paragraph).

Statistical analysis

Frequencies and percentages were used for descriptive categorical variables (such as sex and insurance status), and means with SD were used for continuous variables (such as length of stay). The χ^2 test of independence and Fisher's exact test were applied to stratify the outcome according to the patients' and hospital-level characteristics. A one-way analysis of variance test was applied to assess the difference in the LOS by CCI. The outcomes assessed with stratification included complications, in-hospital mortality, and mean survival (in days). The product limit (Kaplan-Meier) method was used to estimate the mean survival time of patient-level independent factors, where LOS was restricted to less than or equal to 30 days; this was done to avoid skewness in the mean survival time as 99.65% of patients had an LOS of <30 days. Log-rank test was applied to identify differences in the survival functions across different CCI categories.

Univariate analysis was conducted using simple logistic regression to obtain crude odds ratios (ORs) with their corresponding 95% confidence interval (CI) for complications with a screening p value of <0.25. Variables qualifying the screening p value, then entered multivaribale analysis using multiple logistic regression to obtain an adjusted OR with 95% CI. Simple Cox regression with Weibull distribution (parametric) was used to obtain crude hazard ratios (HRs) for inpatient mortality. Multiple Cox regression with Weibull distribution was used to compute adjusted HRs (AHRs) with 95% CI to identify predictors for mortality in primary index EGS admission patients. Final multivariable models were also stratified based on surgical intervention status. A p value of <0.05 was considered significant (two-tailed). All statistical analyses were performed using Stata statistical software (2018, V.15.1 Mac; StataCorp, College Station, Texas, USA).

We also performed competing risk analyses to obtain cumulative incidence of mortality and complications across CCI categories. For inpatient mortality, complications were treated as a competing risk, and for complications, inpatient mortality was treated as a competing risk. Patients who developed complications and subsequently died were classified under complications (as that was the first event that happened). Patients with no events (neither death nor complications) were classified as event type none. Subdistribution HRs were obtained using the Fine and Gray method to account for competing risks; cumulative incidence functions were plotted from those HRs for each CCI category over 30 days.

RESULTS

A total of 32 280 patients with a primary EGS diagnosis at index admission were analyzed. Our patient cohort had a near-equal gender distribution with a slight male predominance (53.50%) and a mean age of 40.06±16.87 years. A striking majority of the patients paid out of pocket for their hospital expenses (76.41%). The overall inpatient mortality rate was 2.42%. The most commonly presenting EGS condition was biliary tract diseases (31.88%), followed by abdominal hernias (9.95%), skin and subcutaneous tissue infections (8.73%), appendicitis and other appendiceal conditions (6.64%), and pancreatic disorders (4.75%); thereby constituting the five most common EGS conditions in our population.

Table 1 describes the demographic case mix of the study cohort, stratified according to outcomes. Increasing age, male gender, residing at a distance from a tertiary healthcare facility, emergent admissions, increasing comorbid severity, and uninsured status were significantly associated with increased complications and deaths from EGS, resulting in overall worse outcomes (p value <0.001). While men were more likely to develop complications, our results showed a lower mean survival time in women (23.21 days) than men (24.86 days).

The overall rate of having a comorbid condition was 44.6%. Of all the components assessed in the CCI, the highest burden of comorbidity in our population was from diabetes mellitus without chronic complication (21.50%), followed by malignancy (8.45%) and mild liver disease (6.56%). In EGS patients with comorbid conditions, 30.61% had a mild CCI index. Table 2 describes patient-related factors and outcomes associated with high comorbid severity. In our EGS population, patients who were male (60.81%, p<0.001), of older age (51.30%, p<0.001), did not have financial coverage (89.37%, p<0.001), and who presented emergently (66.53%, p<0.001) were more likely to have a moderate comorbidity index as compared with their counterparts. The overall rate of developing complications

Table 1 Demographic case matrix

Variable	Total N (%)	Presence of complications		Deaths		Mean survival time (in days)
		n (%)	P value	n (%)	P value	
Sex						
Female	15 010 (46.50)	5178 (34.50)	<0.001	348 (2.32)	0.270	23.21
Male	17 268 (53.50)	6563 (38.01)		433 (2.51)		24.86
Age category						
18–40	10 989 (35.11)	3837 (34.40)	<0.001	161 (1.44)	<0.001	24.69
41–60	12 147 (38.81)	4186 (33.59)		262 (2.10)		24.75
≥61	8161 (26.08)	3718 (42.91)		358 (4.13)		23.33
Residency						
Within city	25 731 (79.71)	9117 (35.43)	<0.001	580 (2.25)	<0.001	23.99
Outside city	6549 (20.29)	2624 (40.07)		201 (3.07)		24.73
Insurance status						
Insured	7615 (23.59)	2288 (30.05)	<0.001	66 (0.87)	<0.001	25.54
Self-paid	24 665 (76.41)	9.453 (38.33)		715 (2.90)		24.07
Admission source						
Elective	17 467 (54.11)	3831 (21.93)	<0.001	100 (0.57)	<0.001	25.48
Emergent	14 813 (45.89)	7910 (53.40)		681 (4.60)		23.56
CCI						
None	17 882 (55.40)	4807 (26.88)	<0.001	79 (0.44)	<0.001	27.46
Mild (1–2)	9880 (30.61)	4288 (43.40)		254 (2.57)		24.86
Moderate (3–4)	1891 (5.86)	1347 (71.23)		199 (10.52)		20.04
Severe (≥5)	2627 (8.14)	1299 (49.45)		249 (9.48)		21.95
Surgical intervention						
Operated	23 588 (73.07)	7739 (32.81)	0.961	390 (1.65)	<0.001	21.22
Non-operated	8.692 (26.93)	4002 (46.04)		391 (4.50)		25.11

The p-values shown here are obtained using chi-square test of independence.
CCI, Charlson Comorbidity Index.

from EGS—regardless of having undergone a procedure—was 36.37%. The three most common complications were sepsis (n=10 388), followed by surgical-site infections (n=3141), and septic shock (n=2447). Of all the patients who developed complications, most of them had moderate-to-severe comorbid index. Patients with higher comorbid severity had a longer mean length of stay (5.83±5.69) compared with patients with no, mild, and moderate CCI severity. The highest mortality rate was observed in those with a moderate comorbidity index (10.52%).

Figure 2 shows Kaplan-Meier survival analysis of EGS index admissions based on the CCI index. The 30-day survival probability was lowest among patients with moderate CCI (20.04; SE 0.64) as compared with the people with no (27.41; SE 0.43), mild (24.86; SE 0.45), and severe (21.95; SE 0.52) CCI. Moderate comorbidity suggests the lowest probability of survival at the end of 30 days (Log rank χ^2=409.81; p value<0.001). Additional analysis showed a considerably higher mortality rate in the severe CCI group within 7 days of hospital LOS (5.75%).

Unadjusted odds of developing complications from EGS showed older age (OR=1.43, 95% CI=1.35, 1.51), uninsured individuals (OR=1.46, 95% CI=1.36, 1.52), emergent admissions (OR=4.07, 95% CI=3.88, 4.28), and those with moderate comorbid severity (OR=6.73, 95% CI=6.06, 7.47) had higher odds of developing complications. Male gender (OR=1.16, 95% CI=1.11, 1.21) and living far from a tertiary healthcare center (OR=1.21, 95% CI=1.15, 1.28) also had similar yet significant odds of predicting complications. The highest odds of complications were in patients with known comorbid mild liver disease (OR=12.14 95% CI=10.70, 13.71) and congestive heart failure (OR=8.67, 95% CI=6.83, 10.99).

Multiple logistic regression analysis showed that CCI was significantly associated with complications, with the highest odds observed in those with moderate comorbidity (AOR=6.61, 95% CI=5.91, 7.37). The model was adjusted for sex, age, residency, insurance status, and surgical intervention. Those who underwent an operation have the lowest odds of developing complications from EGS (table 3). After stratification on surgical intervention, the model showed that patients with moderate comorbid severity who did not undergo surgery had higher odds of developing complications than operated patients (AOR=7.36 vs 6.36, respectively). Increasing age significantly increases the odds of complications in the non-operated group compared with the operated group, in which increasing age leads to decreased odds of complications. No healthcare coverage significantly increased the odds of complications in both non-operated and operated groups.

Unadjusted HRs of patient characteristics associated with inpatient mortality from EGS showed that severe comorbidity index was independently associated with the highest mortality risk from EGS (HR=7.42, 95% CI=5.72, 9.63). Male (HR=0.85, 95% CI=0.73, 0.98), older age (HR=2.05, 95% CI=1.70, 2.49), lack of financial insurance (HR=1.82, 95% CI=1.41, 2.35), and emergent admission (HR=3.29, 95% CI=2.65, 4.09) were all associated with inpatient mortality. Similarly, patients with comorbid conditions of moderate-to-severe liver disease (HR=5.26, 95% CI=4.11, 6.73), congestive heart failure (HR=3.51, 95% CI=2.89, 4.27), those who developed complications of cardiac arrest (HR=24.76, 95% CI=21.03, 19.14), and septic shock (HR 8.23, 95% CI 6.95, 9.74) were also found to be independently associated with the highest risk of mortality from EGS.

Table 2 Patient-related factors and outcomes associated with high comorbid severity in EGS

Variable	None CCI n (%)	Mild CCI n (%)	Moderate CCI n (%)	Severe CCI n (%)	P value
Sex					
Female	8676 (48.52)	4403 (44.57)	741 (39.19)	1190 (45.30)	<0.001
Male	9205 (51.48)	5476 (55.43)	1150 (60.81)	1437 (54.70)	
Age, in years					
18–40	8905 (49.80)	1649 (16.69)	185 (9.78)	416 (15.84)	<0.001
41–60	6280 (35.12)	4325 (43.78)	736 (38.92)	1120 (42.63)	
>61	2697 (15.08)	3906 (39.53)	970 (51.30)	1091 (41.53)	
Residency					
Within city	14 586 (81.57)	7709 (78.03)	1417 (74.93)	2019 (76.86)	<0.001
Outside city	3296 (18.43)	2171 (21.97)			
Payer status					
Insured	5507 (30.80)	1622 (16.42)	201 (10.63)	285 (10.85)	<0.001
Self-paid	12 375 (69.20)	8258 (83.58)	1690 (89.37)	2342 (89.15)	
Admission status					
Elective	10 939 (61.17)	4784 (48.72)	633 (33.47)	1111 (42.49)	<0.001
Emergent	6943 (38.83)	5096 (51.58)	1258 (66.53)	1516 (57.71)	
Complications					
Cardiac arrest	84 (0.47)	242 (2.45)	167 (8.83)	176 (6.70)	<0.001
Myocardial Infarction*	0	161 (1.63)	159 (8.41)	126 (4.80)	<0.001
DVT/PE	49 (0.27)	56 (0.57)	20 (1.06)	55 (2.09)	<0.001
CVA/stroke*	0	19 (0.19)	18 (0.95)	17 (0.65)	<0.001
Coma	11 (0.06)	17 (0.17)	9 (0.48)	8 (0.30)	<0.001
Acute renal failure	297 (1.66)	773 (7.82)	593 (31.36)	504 (19.19)	<0.001
UTI/cystitis	169 (0.95)	340 (3.44)	130 (6.87)	171 (6.51)	<0.001
Pneumonia	133 (0.74)	243 (2.46)	120 (6.35)	141 (5.37)	<0.001
Pulmonary failure/ARDS	203 (1.14)	320 (3.24)	205 (10.84)	186 (7.08)	<0.001
Sepsis	4524 (25.30)	3657 (37.01)	1127 (59.60)	1080 (41.11)	<0.001
Septic shock	354 (1.98)	886 (8.97)	642 (33.95)	565 (21.51)	<0.001
SSI	1169 (6.54)	1312 (13.28)	350 (18.51)	310 (11.80)	<0.001
Pseudomembranous colitis*	6 (0.03)	17 (0.17)	0	3 (0.11)	0.001
Hemorrhage	81 (0.45)	349 (3.53)	118 (6.24)	102 (3.88)	<0.001
Gastrointestinal bleeding	41 (0.23)	324 (3.28)	111 (5.87)	93 (3.54)	<0.001
Length of stay (mean±SD)†	2.62+3.45	3.93±4.80	5.72±7.37	5.83±5.69	<0.001

The χ^2 test for independence is applied.
*Fisher's exact test applied.
†One-way ANOVA test applied.
ANOVA, analysis of variance; ARDS, adult respiratory distress syndrome; CCI, Charlson Comorbidity Index; DVT, deep vein thrombosis; EGS, Emergency General Surgery; PE, pulmonary embolism; UTI, urinary tract infection.

On adjusting for covariates (table 4), patients with severe comorbidity had the highest hazards (AHR=3.79, 95% CI=2.89, 4.98), and operated patients (AHR=0.42, 95% CI=0.36, 0.49) had the lowest hazards of dying compared with their counterparts. The stratification on operative status showed older patients who were operated on had a significantly higher risk of mortality compared with non-operated patients (HR=2.05 vs 0.60). Septic shock and sepsis were both independently associated with inpatient mortality in non-operated and operated groups.

Figure 3 shows the graphical representation of competing risks for mortality and complication by day 30. Patients with severe CCI showed the highest cumulative mortality rate, approximately reaching 15%, followed by moderate CCI (10%), mild CCI (5%), and no comorbidities (2%). The cumulative incidence of complications was highest in patients with moderate CCI, reaching approximately 8%, followed by severe CCI (6%), mild CCI (3%), and no comorbidity (1%).

DISCUSSION

This retrospective analysis of 32 280 patients with a primary EGS diagnosis at admission revealed: (1) biliary tract diseases, abdominal hernias, and skin and subcutaneous tissue infections as the most common causes of emergency surgery. (2) Patients with moderate-to-severe comorbidities index have poor post-operative outcomes and reduced survival. (3) Gender was also an important factor, which showed males having higher odds of developing complications but lower hazards of inpatient mortality. (4) Living outside the city and lack of health insurance were further associated with an increased risk of EGS-related complications.

The five most common EGS conditions highlighted in our population were biliary tract diseases, abdominal hernias, skin and subcutaneous tissue infections, appendicitis and other appendiceal conditions, and pancreatic disorders. This finding is consistent with the literature; however, the rankings of these

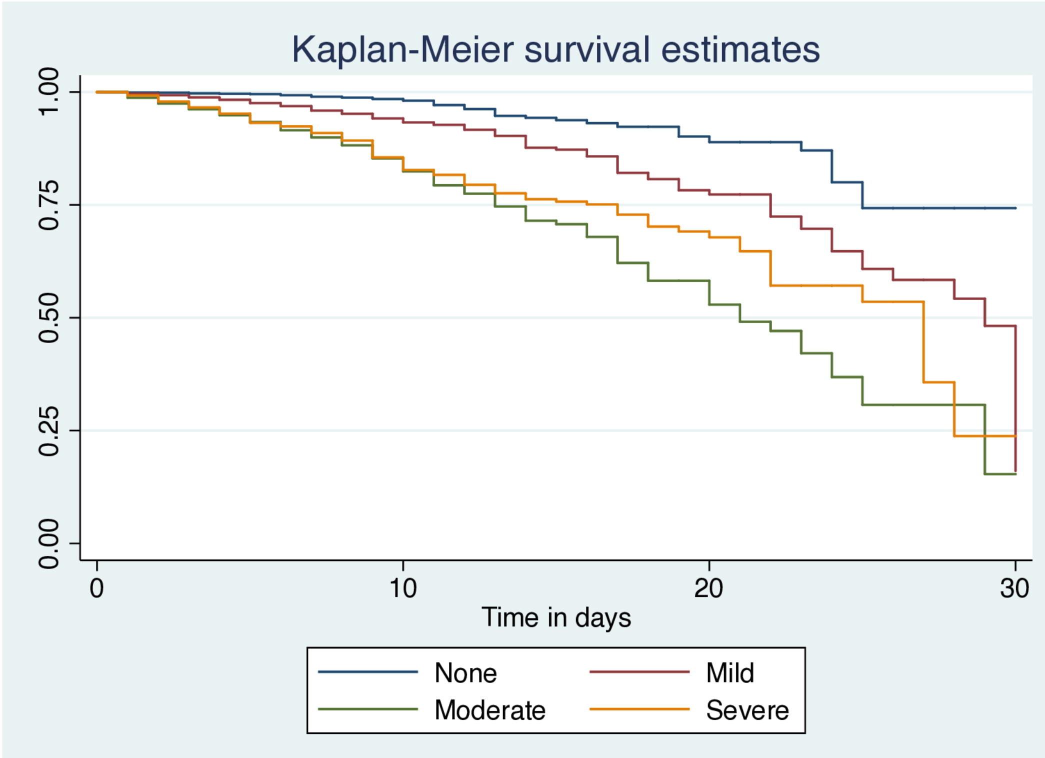

Figure 2 Kaplan-Meier 30-day survival plot for comorbid severity. Note: censored patients were those who remained alive at the time of discharge. Time to event was the death of the patient during their hospital length of stay.

conditions vary depending on the study's population and characteristics. Similar to our results, a 4-year national retrospective analysis in the USA revealed cholecystectomy, appendectomy, and laparotomy among the top seven EGS procedures.[16] However, partial colectomy and small bowel resection were the most common emergency procedures.[16] Furthermore, a national database from England also indicated acute appendicitis, gallstone disease, diverticular disease, abdominal wall hernia, or intestinal obstruction to be the most common conditions requiring emergency surgery.[17] Limited literature from Pakistan additionally supports alimentary tract conditions as the top emergent condition.[18]

Table 3 Adjusted odds with 95% CI of developing complications using multiple logistic regression

	Adjusted odds ratio (95% CI)		
Variables	**Overall**	**Non-operated**	**Operated**
CCI (Ref: none)			
Mild	2.13 (2.01, 2.25)	2.43 (2.19, 2.70)	2.07 (1.94, 2.22)
Moderate	6.61 (5.91, 7.37)	7.36 (6.11, 8.88)	6.36 (5.55, 7.30)
Severe	2.60 (2.38, 2.84)	2.83 (2.45, 3.28)	2.48 (2.21, 2.77)
Sex (Ref: female)			
Males	1.09 (1.04, 1.15)	1.15 (1.05, 1.27)	1.08 (1.02, 1.15)
Age (Ref: 18–40 years)			
41–60	0.70 (0.66, 0.74)	1.37 (1.21, 1.54)	0.56 (0.52, 0.60)
>61	0.81 (0.76, 0.87)	1.79 (1.58, 2.02)	0.58 (0.52, 0.63)
Residency (Ref: within city)			
Outside city	1.11 (1.05, 1.18)	1.10 (0.98, 1.23)	1.15 (1.07, 1.23)
Insurance status (Ref: insured)			
Self-paid	1.14 (1.07, 1.21)	1.21 (1.07, 1.37)	1.14 (1.06, 1.22)
Surgical intervention (Ref: non-operated)		–	–
Operated	0.68 (0.65, 0.72)		

CCI, Charlson Comorbidity Index.

Table 4 Adjusted HRs with 95% CI for EGS associated in-hospital mortality

Variables	**Adjusted HR (95% CI)**		
	Overall	Non-operated	Operated
CCI (Ref: none)			
Mild	2.09 (1.60, 2.73)	3.68 (2.32, 5.86)	1.36 (0.97, 1.91)
Moderate	3.20 (2.41, 4.23)	5.26 (3.29, 8.74)	2.27 (1.60, 3.21)
Severe	3.79 (2.89, 4.98)	6.14 (3.84, 9.83)	2.78 (1.97, 3.92)
Sex (Ref: female)			
Males	0.84 (0.73, 0.98)	0.97 (0.78, 1.19)	0.72 (0.60, 0.90)
Age (Ref: 18–40 years)			
41–60	0.90 (0.73, 1.11)	0.67 (0.51, 0.90)	1.23 (0.91, 1.65)
>61	1.07 (0.88, 1.31)	0.60 (0.46, 0.79)	2.05 (1.52, 2.78)
Insurance status (Ref: insured)			
Self-paid	1.39 (1.07, 1.79)	1.60 (1.07, 2.39)	1.32 (0.94, 1.84)
Surgical intervention (Ref: non-operated)		–	–
Operated	0.42 (0.36, 0.49)		
Septic shock (Ref: without)	4.02 (3.36, 4.82)	3.59 (2.81, 4.58)	4.38 (3.37, 5.69)
Sepsis (Ref: without)	2.36 (1.90, 2.92)	1.83 (1.39, 2.41)	3.38 (2.37, 4.82)

EGS, Emergency General Surgery.

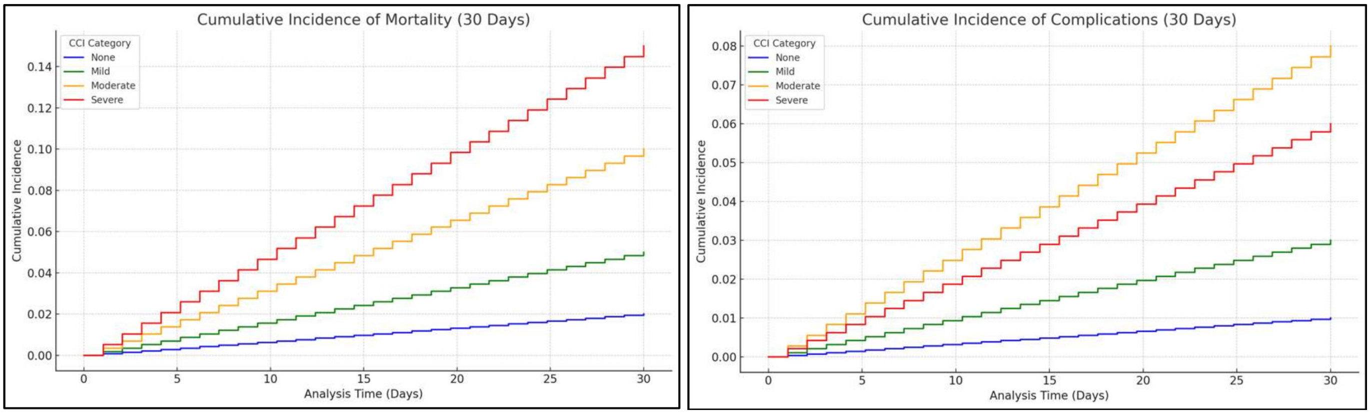

Figure 3 Competing risk analysis for cumulative incidence. CCI, Charlson Comorbidity Index

The risk of adverse outcomes after EGS is amplified in the presence of comorbidities.[19 20] These include an increased risk of postoperative complications, which ultimately prolong the length of stay and increase 30-day mortality.[21 22] The results from the 2016–2018 Nationwide Readmissions Database (NRD) concluded that the increasing severity of chronic kidney disease is associated with an increased risk of adverse events postoperatively.[23] Patients with end-stage renal disease undergoing appendectomy also have 1.5 times greater chances of developing mechanical wound complications as compared with other patients.[24] Comorbidities such as diabetes mellitus and HIV/AIDS have also been reported to increase postoperative complication risks,[25–27] indicating the diverse impact of various comorbidities on EGS outcomes. Our results highlighted that patients with moderate CCI had higher odds of complications than patients with severe CCI. The possible explanation for this could be that patients with severe comorbidities may experience higher mortality (as seen from higher hazards of mortality in severe CCI in our study and early mortality in the Kaplan-Meier plot), which may skew the complication rates downwards—the 'survivor bias.' The hypothesis was further investigated in our study through competing risk analysis; patients with severe CCI experience higher early mortality and a higher cumulative mortality incidence by day 30, which reduces their likelihood of surviving long enough to develop complications, leading to an apparent ambiguity of lower complication likelihood compared with patients with moderate CCI.

Our results concluded that patients aged greater than 60 years of age, male gender, undergoing emergency admission, residing outside the city, and being uninsured have moderate-to-severe comorbidities, adversely affecting their EGS outcomes. A previous study using the Charlson Age-Comorbidity Index (CACI) to predict 30-day mortality after EGS reported similar findings where patients aged greater than 65 years had higher mortality.[1] These findings are consistent with a narrative review identifying increased post-EGS mortality in the geriatric population.[28] Another study has indicated that the presence of liver disease adds to the mortality burden in the geriatric population undergoing EGS.[29] Furthermore, our study indicated higher hazards of mortality in older patients undergoing surgical intervention. A possible reason for this is the increased complexity of the disease at presentation in the older population due to severe comorbidity status,[30] accentuating proper control of comorbidities at presentation and requiring surgical management. Additionally, patients with cirrhosis have more than twice the risk of 90-day mortality, indicating a long-term influence of liver diseases postcolectomy.[31] Cauley *et al* showed a greater rate of 30-day mortality and complications after emergency abdominal surgery in patients with metastatic cancer.[32] Moreover, such patients presenting with obstructive symptoms have a median survival of only 3 months, regardless of operative or non-operative treatment.[33] Early palliative care in such patients has been shown to extend survival.[34] Therefore, thorough documentation and assessment of patients presenting with EGS conditions should be done to implement patient-specific strategies to ascertain improved outcomes. Even though previous studies highlight males to have increased mortality post-EGS, the impact of patient gender on postoperative complications and mortality becomes insignificant when adjusted for comorbidities,[35–37] which is not consistent with our study; males had lower hazards of inpatient mortality, but higher odds of complications.

Congruent to our findings, a population-based cohort study in Scotland concluded similar results, where approximately 56% of its EGS admissions with moderate-to-severe CCI scores lived at a distance of >15 km from their admitting hospital.[38] Increased distance from the hospital is associated with higher postoperative complications in patients undergoing EGS.[39] Similarly, patients residing in rural Australia are reported to have multiple unidentified comorbidities, which ultimately leads to an increased rate of preventable mortality after surgery.[40] Furthermore, since rural residents have a higher likelihood of being uninsured, they are prone to a higher rate of postoperative adverse consequences owing to their pre-existing comorbidities.[41] Hence, financial disparities of the patient also play a vital role in predicting their health-related outcomes. Economically deprived patients are more likely to have a higher CCI score, often with an array of unidentified comorbid conditions.[41] Consequently, these patients have an increased risk of death, as shown by a national observational study from England that highlighted higher risk-adjusted 30-day mortality in such patients after undergoing emergency laparotomy.[42] Uninsured patients have a higher rate of postoperative complications than insured patients.[43] Additionally, another study concluded uninsured patients have a higher rate of in-hospital mortality after undergoing major surgical procedures as compared with their counterparts after adjusting for comorbidities.[44]

Comparing our findings with the EGS patients in high-resource settings, it is interesting to note that while our mortality rate is 2.42%, Mark *et al*'s study with 19956 EGS patients from 10 hospitals in the USA reported an aggregate mortality of 3.5%.[45] However, the proportion of patients undergoing surgical intervention in our study (73.07%) was similar to Mark *et al* (77.08%). Another striking difference between these two studies is the difference in payer status, where our study had 76.41% self-payors, compared with only 1.9%

in the USA. This difference could be due to the missing data (15.3% for payment status) in Mark *et al*'s study and the easy access and availability of insurance through Medicaid/Medicare programs in the USA.[45] Another study across three high-income countries (Australia, England, and the USA) showed that only 27% of 69490 patients underwent emergency abdominal surgery,[46] owing to the inclusion of only high-risk patients. While our study showed an increasing mean LOS for EGS patients, with 2.62 days for those without any comorbidity, the literature for high-resource settings showed a lower LOS for most patients.[47 48] Since patients are often discharged to rehabilitation or skilled care facilities for further management in high-resource settings,[47] this reduces their LOS at the hospital, while it stays increased for low-income countries owing to the lack of such resources. Understanding these differences in both the demographics and hospitalization variables of EGS patients between low-income and high-income countries is critical for contextually relevant actions that could result in optimal outcomes.

Since the use of primary care has shown reduced postoperative mortality for EGS patients through timely diagnosis and management of comorbidities,[49] healthcare leaders and policymakers should advocate for advancing primary care in low-resource settings. This would reduce postoperative complications and reduce LOS for EGS patients, ultimately lowering hospital costs specifically for those paying out-of-pocket. Increasing resources for primary care expansion by allocating greater government spending and encouraging community involvement could increase access for the public in low-income countries.[50] Similar to our results, it has been noted that the presence of any comorbidity significantly increases the chances of sepsis for general surgery patients.[51] For patients at increased risk of post-EGS complications such as sepsis, the use of a screening tool like quick Sepsis-related Organ Failure Assessment (qSOFA) is recommended for timely diagnosis and appropriate management to prevent poor outcomes.[51] Use of multidisciplinary teams during both the preoperative and postoperative periods can further ensure specialized screening and treatment for patients with multiple comorbidities. This can be accomplished through interdisciplinary team meetings with discussions about high-complexity patients and their comorbidity/frailty index, which can allow input from multiple providers for positive outcomes for patients.[52] While allocating funds and resources and developing multidisciplinary teams should be prioritized in low-resource settings, these facilities are generally available in high-income countries, where optimal use of such resources and encouraging screening tools to reduce preventable postoperative complications should be emphasized.

This study has several strengths. The relatively large sample size is the greatest strength of our study since it allowed drawing conclusions that can be generalizable to the country's population. Even though this sample has been taken from a single academic medical center, the provision of its diverse services to patients from various backgrounds further permits extrapolating the findings to the general population. Limited studies have been published within the South Asian region related to this topic, thereby making the results of our study a valid addition to the literature. Additionally, the findings highlighted in our study pave the way for healthcare leaders to develop context-specific prognostic tools for EGS conditions and validate them in critical and non-critical settings,[53] which can standardize their adaptation in low-resource settings and improve outcomes. However, this study is not without its limitations. Since this is a retrospective study, several variables are not accounted for within the analysis, which would have provided further insight regarding the research question, such as prior operations, medications, and so on. However, a multilevel analysis was performed with the available demographic information to conclude their effect on health-related outcomes. Furthermore, only short-term outcomes were considered since the database did not collect the incidence of complications or mortality after patients were discharged. While there is also a possibility of miscoded diagnoses or procedures with such extensive data,[54] the database used in our study to extract variables is generally reliable and of sufficient quality.

The findings of our study provide an overview of the adverse impact caused by the excessive burden of comorbidities within our patients and identify patient-level factors predicting higher CCI and worse outcomes in EGS. This encourages the use and integration of CCI in assessing patients presenting with EGS conditions to help determine population subsets at risk of worse outcomes. This can help provide valuable insight on disease progression and aid decision-making in EGS patients in countries where data on comorbid conditions is not well documented. In a clinical context, CCI and patient-level factors identified in this study can be incorporated into the prognostic models that guide clinical prioritization, resource allocation, and individualized care strategies in EGS patients—this will help stratify the patients with their risk of complications and mortality. Alongside the prognostic model, a scoring system can be developed that assists clinicians in assessing the risks efficiently, especially in low-income and middle-income countries where there is a lack of extensive diagnostic capabilities. Moreover, it showcases a dire need for awareness among the population regarding the effect of comorbidities, as early recognition and control can help improve survival and prevent complications. Thus, relevant agencies must act by disseminating preventative and maintenance efforts for common comorbidities, ultimately decreasing the overall morbidity and mortality rate secondary to non-communicable diseases.

Contributors KAR: conceptualization, project administration, methodology, software, formal analysis, investigation, data curation, writing – original draft. NQS: conceptualization, methodology, software, formal analysis, investigation, data curation, writing – original draft. MPAL: methodology, software, formal analysis, data curation. AAHM: investigation, data curation, writing – original draft. NA: investigation, data curation, writing – original draft. SbZM: writing – review and editing. SKB: writing – review and editing. MA: review and editing. ZS: supervision, writing – review and editing. AHH: conceptualization, supervision, writing – review and editing. KAR and Dr SbZM are the guarantor of this work.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval Since this study did not involve any direct interaction with patients, it was exempted from review by the ethical review committee (ERC) of the Aga Khan University (Reference # 2021-6878-20016).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information. All data relevant to the study are included in the article.

ORCID iDs
Komal Abdul Rahim http://orcid.org/0000-0002-0790-6644
Asma Altaf Hussain Merchant http://orcid.org/0000-0002-0393-2079

REFERENCES

1 St-Louis E, Iqbal S, Feldman LS, Sudarshan M, Deckelbaum DL, Razek TS, Khwaja K. Using the age-adjusted Charlson comorbidity index to predict outcomes in emergency general surgery. *J Trauma Acute Care Surg* 2015;78:318–23.
2 Shah AA, Latif A, Zogg CK, Zafar SN, Riviello R, Halim MS, Rehman Z, Haider AH, Zafar H. Emergency general surgery in a low-middle income health care setting: Determinants of outcomes. *Surgery* 2016;159:641–9.

3 Charlson ME, Carrozzino D, Guidi J, Patierno C. Charlson Comorbidity Index: A Critical Review of Clinimetric Properties. *Psychother Psychosom* 2022;91:8–35.
4 Shah AA, Haider AH, Zogg CK, Schwartz DA, Haut ER, Zafar SN, Schneider EB, Velopulos CG, Shafi S, Zafar H, *et al*. National estimates of predictors of outcomes for emergency general surgery. *J Trauma Acute Care Surg* 2015;78:482–90;
5 Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40:373–83.
6 Charlson comorbidity index (cci). Available: https://www.mdcalc.com/calc/3917/charlson-comorbidity-index-cci [Accessed 23 Feb 2024].
7 Laor A, Tal S, Guller V, Zbar AP, Mavor E. The Charlson Comorbidity Index (CCI) as a Mortality Predictor after Surgery in Elderly Patients. *Am Surg* 2016;82:22–7.
8 Sirag A, Mohamed Nor N. Out-of-Pocket Health Expenditure and Poverty: Evidence from a Dynamic Panel Threshold Analysis. *Healthcare (Basel)* 2021;9:536.
9 Brinkhof MWG, Pujades-Rodriguez M, Egger M. Mortality of patients lost to follow-up in antiretroviral treatment programmes in resource-limited settings: systematic review and meta-analysis. *PLoS One* 2009;4:e5790.
10 Joglekar N, Paranjape R, Jain R, Rahane G, Potdar R, Reddy KS, Sahay S. Barriers to ART adherence & follow ups among patients attending ART centres in Maharashtra, India. *Indian J Med Res* 2011;134:954–9.
11 Geng EH, Bangsberg DR, Musinguzi N, Emenyonu N, Bwana MB, Yiannoutsos CT, Glidden DV, Deeks SG, Martin JN. Understanding reasons for and outcomes of patients lost to follow-up in antiretroviral therapy programs in Africa through a sampling-based approach. *J Acquir Immune Defic Syndr* 2010;53:405–11.
12 Khalid M, Shahid S, Ilyas S, Zia Ud D. Audit of medical record documentation of patients admitted to a medical unit in a teaching hospital NWFP Pakistan. 2007:113–6.
13 Muzaffar F, Fatima N, Fawwad A, Riaz M. Adherence of healthcare professionals to American Diabetes Association 2004 guidelines for the care of patients with type 2 diabetes at peripheral diabetes clinics in Karachi, Pakistan. *Pak J Med Sci* 2013;29:474.
14 Shafi S, Aboutanos MB, Agarwal S Jr, Brown CVR, Crandall M, Feliciano DV, Guillamondegui O, Haider A, Inaba K, Osler TM, *et al*. Emergency general surgery: definition and estimated burden of disease. *J Trauma Acute Care Surg* 2013;74:1092–7.
15 Abdul Rahim K, Shaikh NQ, Lakhdir MPA, Afzal N, Merchant AAH, Mahmood SBZ, Bakhshi SK, Ali M, Samad Z, Haider AH. No healthcare coverage, big problem: lack of insurance for older population associated with worse emergency general surgery outcomes. *Trauma Surg Acute Care Open* 2024;9:e001165.
16 Scott JW, Olufajo OA, Brat GA, Rose JA, Zogg CK, Haider AH, Salim A, Havens JM. Use of National Burden to Define Operative Emergency General Surgery. *JAMA Surg* 2016;151:e160480.
17 Hutchings A, O'Neill S, Lugo-Palacios D, Moler Zapata S, Silverwood R, Cromwell D, Keele L, Bellingan G, Moonesinghe SR, Smart N, *et al*. Effectiveness of emergency surgery for five common acute conditions: an instrumental variable analysis of a national routine database. *Anaesthesia* 2022;77:865–81.
18 Shamim M, Bano S, Iqbal SA. Pattern of cases and its management in a general surgery unit of a rural teaching institution. *J Pak Med Assoc* 2012;62:148–53.
19 Wohlgemut JM, Ramsay G, Griffin RL, Jansen JO. Impact of deprivation and comorbidity on outcomes in emergency general surgery: an epidemiological study. *Trauma Surg Acute Care Open* 2020;5:e000500.
20 Ylimartimo AT, Nurkkala J, Koskela M, Lahtinen S, Kaakinen T, Vakkala M, Hietanen S, Liisanantti J. Postoperative Complications and Outcome After Emergency Laparotomy: A Retrospective Study. *World J Surg* 2023;47:119–29.
21 Dharap SB, Barbaniya P, Navgale S. Incidence and Risk Factors of Postoperative Complications in General Surgery Patients. *Cureus* 2022;14:e30975.
22 Aslam M, Mukhtar S, Ullah Sheikh MU, Gillani S, Wahab F, Masood S. Calculating the Increased Morbidity and Mortality Related with Emergency General Surgery while Adjusting for Patient-Specific Characteristics. *PJMHS* 2022;16:843–5. Available: https://pjmhsonline.com/index.php/pjmhs/issue/view/3.
23 Dobaria V, Hadaya J, Richardson S, Lee C, Tran Z, Verma A, Sanaiha Y, Benharash P. Clinical and financial impact of chronic kidney disease in emergency general surgery operations. *Surg Open Sci* 2022;10:19–24.
24 Smith MC, Boylan MR, Tam SF, Lee R, Alfonso AE, Sugiyama G. End-stage renal disease increases the risk of mortality after appendectomy. *Surgery* 2015;158:722–7.
25 Sandler BJ, Davis KA, Schuster KM. Symptomatic human immunodeficiency virus-infected patients have poorer outcomes following emergency general surgery: A study of the nationwide inpatient sample. *J Trauma Acute Care Surg* 2019;86:479–88.
26 Levy N, Penfold NW, Dhatariya K. Perioperative management of the patient with diabetes requiring emergency surgery. *BJA Education* 2017;17:129–36.
27 Ata A, Lee J, Bestle SL, Desemone J, Stain SC. Postoperative hyperglycemia and surgical site infection in general surgery patients. *Arch Surg* 2010;145:858–64.
28 Desserud KF, Veen T, Søreide K. Emergency general surgery in the geriatric patient. *Br J Surg* 2016;103:e52–61.
29 Ho VP, Schiltz NK, Reimer AP, Madigan EA, Koroukian SM. High-Risk Comorbidity Combinations in Older Patients Undergoing Emergency General Surgery. *J Am Geriatr Soc* 2019;67:503–10.
30 Deverakonda DL, Kishawi SK, Lapinski MF, Adomshick VJ, Siff JE, Brown LR, Ho VP. What If We Do Not Operate? Outcomes of Nonoperatively Managed Emergency General Surgery Patients. *J Surg Res* 2023;284:29–36.
31 Adiamah A, Crooks CJ, Hammond JS, Jepsen P, West J, Humes DJ. Mortality following elective and emergency colectomy in patients with cirrhosis: a population-based cohort study from England. *Int J Colorectal Dis* 2022;37:607–16.
32 Cauley CE, Panizales MT, Reznor G, Haynes AB, Havens JM, Kelley E, Mosenthal AC, Cooper Z. Outcomes after emergency abdominal surgery in patients with advanced cancer: Opportunities to reduce complications and improve palliative care. *J Trauma Acute Care Surg* 2015;79:399–406.
33 Pameijer CR, Mahvi DM, Stewart JA, Weber SM. Bowel obstruction in patients with metastatic cancer: Does intervention influence outcome. *Int J Gastrointest Cancer* 2005;35:127–33.
34 Gaertner J, Wolf J, Voltz R. Early palliative care for patients with metastatic cancer. *Curr Opin Oncol* 2012;24:357–62.
35 He JW, Sun LY, Wijeysundera D, Vogt K, Jones PM. Patient Sex and Postoperative Outcomes after Inpatient Intraabdominal Surgery: A Population-based Retrospective Cohort Study. *Anesthesiology* 2022;136:577–87.
36 Rucker D, Warkentin LM, Huynh H, Khadaroo RG. Sex differences in the treatment and outcome of emergency general surgery. *PLoS One* 2019;14:e0224278.
37 Peterson CY, Osen HB, Tran Cao HS, Yu PT, Chang DC. The battle of the sexes: women win out in gastrointestinal surgery. *J Surg Res* 2011;170:e23–8.
38 Wohlgemut JM, Ramsay G, Bekheit M, Scott NW, Watson AJM, Jansen JO. Emergency general surgery: impact of distance and rurality on mortality. *BJS Open* 2022;6:zrac032.
39 Mitchell A, Drevets P, Ramsey W, Holsten S. Distance from Hospital and Surgical Outcomes in Emergency General Surgery. *Am Surg* 2019;85:e479–80.
40 Liu J, Ting YY, Trochsler M, Reid J, Anthony A, Maddern G. Analysis of surgical mortality in rural South Australia: a review of four major rural hospital in South Australia. *ANZ J Surg* 2022;92:1681–91. Available: https://onlinelibrary.wiley.com/toc/14452197/92/7-8.
41 de Jager E, Chaudhary MA, Rahim F, Jarman MP, Uribe-Leitz T, Havens JM, Goralnick E, Schoenfeld AJ, Haider AH. The Impact of Income on Emergency General Surgery Outcomes in Urban and Rural Areas. *J Surg Res* 2020;245:629–35.
42 Poulton TE, Moonesinghe R, Raine R, Martin P, National Emergency Laparotomy Audit project team. Socioeconomic deprivation and mortality after emergency laparotomy: an observational epidemiological study. *Br J Anaesth* 2020;124:73–83.
43 Shahan CP, Bell T, Paulus E, Zarzaur BL. Emergency general surgery outcomes at safety net hospitals. *J Surg Res* 2015;196:113–7.
44 LaPar DJ, Bhamidipati CM, Mery CM, Stukenborg GJ, Jones DR, Schirmer BD, Kron IL, Ailawadi G. Primary payer status affects mortality for major surgical operations. *Ann Surg* 2010;252:544–50;
45 Hemmila MR, Neiman PU, Hoppe BL, Gerhardinger L, Kramer KA, Jakubus JL, Mikhail JN, Yang AY, Lindsey HJ, Golden RJ, *et al*. Improving outcomes in emergency general surgery: Construct of a collaborative quality initiative. *J Trauma Acute Care Surg* 2024;96:715–26.
46 Chana P, Joy M, Casey N, Chang D, Burns EM, Arora S, Darzi AW, Faiz OD, Peden CJ. Cohort analysis of outcomes in 69 490 emergency general surgical admissions across an international benchmarking collaborative. *BMJ Open* 2017;7:e014484.
47 Rossi IR, Ross SW, May AK, Reinke CE. Readmission After Emergency General Surgery: NSQIP Review of Risk, Cause and Ideal Follow-Up. *J Surg Res* 2021;260:359–68.
48 Ramsay G, Wohlgemut JM, Jansen JO. Emergency general surgery in the United Kingdom: A lot of general, not many emergencies, and not much surgery. *J Trauma Acute Care Surg* 2018;85:500–6.
49 Roberts SE, Rosen CB, Keele LJ, Kaufman EJ, Wirtalla CJ, Finn CB, Moneme AN, Bewtra M, Kelz RR. Association of Established Primary Care Use With Postoperative Mortality Following Emergency General Surgery Procedures. *JAMA Surg* 2023;158:1023–30.
50 Langlois EV, McKenzie A, Schneider H, Mecaskey JW. Measures to strengthen primary health-care systems in low- and middle-income countries. *Bull World Health Organ* 2020;98:781–91.
51 Peden CJ, Aggarwal G, Aitken RJ, Anderson ID, Bang Foss N, Cooper Z, Dhesi JK, French WB, Grant MC, Hammarqvist F, *et al*. Guidelines for Perioperative Care for Emergency Laparotomy Enhanced Recovery After Surgery (ERAS) Society Recommendations: Part 1-Preoperative: Diagnosis, Rapid Assessment and Optimization. *World J Surg* 2021;45:1272–90.
52 Kuiper BI, Janssen LMJ, Versteeg KS, Ten Tusscher BL, van der Spoel JI, Lubbers WD, Kazemier G, Loer SA, Schober P, van Halm VP. Does preoperative multidisciplinary team assessment of high-risk patients improve the safety and outcomes of patients undergoing surgery? *BMC Anesthesiol* 2024;24:9.
53 Havens JM, Columbus AB, Seshadri AJ, Brown CVR, Tominaga GT, Mowery NT, Crandall M. Risk stratification tools in emergency general surgery. *Trauma Surg Acute Care Open* 2018;3:e000160.
54 Burns EM, Rigby E, Mamidanna R, Bottle A, Aylin P, Ziprin P, Faiz OD. Systematic review of discharge coding accuracy. *J Public Health (Oxf)* 2012;34:138–48.