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Frailty in elderly patients with acute colonic diverticulitis is associated with worse in-hospital outcomes: A nationwide analysis

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Abstract

Background Frailty has been identified as an independent predictor of mortality in the elderly. We investigated the effects of frailty status on in-hospital outcomes of acute colonic diverticulitis (ACD) in the elderly, using the Hospital Frailty Risk Score.

Methods We used the National Inpatient Sample (NIS) databases from 2016-2020 to identify patients aged ≥75 years hospitalized with ACD. Using a 1:1 matching method, we created propensity-matched cohorts of frail (Hospital Frailty Risk Score ≥5) and non-frail (Hospital Frailty Risk Score ≤4) patients within the ACD population.

Results We identified 53.3% ACD patients as frail. We matched 21,720 frail ACD patients to an equal number of non-frail ACD patients using propensity score matching. Frail patients exhibited significantly higher mortality rates, longer hospital stays, and greater median inpatient costs. Frail patients also experienced a greater number of complications, including abscess formation, intestinal perforation, gastrointestinal fistula formation, sepsis without shock, sepsis with shock, acute kidney injury, hypovolemic or hemorrhagic shock, need for blood transfusion, cardiac arrest, and need for intensive care (all P-values <0.001). Additionally, frail patients underwent open colectomy and colostomy procedures more frequently, while laparoscopic colectomies were performed less frequently (all P-values <0.001).

Conclusions In this nationwide analysis, frailty in ACD is strongly associated with worse mortality, longer hospital stays and higher costs, as well as a greater incidence of local and systemic complications. Furthermore, frailty is linked to a greater need for open colectomy and colostomy procedures.

Keywords Acute colonic diverticulitis, frailty, elderly, National Inpatient Sample

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Conflict of Interest: None

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Introduction

Acute colonic diverticulitis (ACD) refers to the inflammation of colonic diverticula, which can occur in approximately 10-25% of individuals with diverticulosis [1]. This condition can lead to various systemic and local complications, including sepsis, pericolonic abscesses formation, fistulas, bowel obstructions, bleeding, and perforations [2]. The risk of developing acute diverticulitis increases with age, ranging from 10% in individuals under 50 years old to 33% in those between 60 and 69 years old [3].

Like ACD, frailty is also believed to be highly prevalent in the elderly [4]. It is defined as a vulnerability to adverse health outcomes secondary to decreased resistance or reserve to

stressors, resulting from a decline in the performance of multiple integrated physiological systems, and it is closely related to aging [5,6]. Various methods have been proposed to assess frailty based on objective performance (phenotypic frailty), such as the Fried Frailty Phenotype, or based on comorbidities, disabilities or social factors (deficit accumulation or index frailty) [5,7]. Various screening tools have been developed based on these methods; however, to date, there is no gold standard method of screening for frailty. This poses a major challenge to the development of successful interventions [8,9]. The presence of frailty can potentially affect inpatient outcomes related to conditions that preferentially affect the elderly, and the identification of frailty in these patients can provide an opportunity for early intervention in the population at risk.

Therefore, we investigated the effects of frailty on in-hospital outcomes of ACD. For this purpose, we used the Hospital Frailty Risk Score, which is based on the International Classification of Diseases, Tenth Revision (ICD-10) codes and was developed using the Hospital Episode Statistics inpatient database [10]. Our study was performed using the National Inpatient Sample (NIS), the largest national inpatient database in the United States of America (USA).

Materials and methods

Data source and study population

The NIS database was searched for hospitalizations related to ACD between the years 2016 and 2020. NIS, recognized as the most extensive all-payer inpatient database in the USA, contains data from 48 states and the District of Columbia, covering over 98 percent of the entire USA population. NIS employs a stratified probability sampling technique, where the stratification is based on multiple factors, such as hospital bed capacity, teaching status, ownership, rural versus urban location, and geographical region. We used the ICD-10-CM classification, as well as procedural codes (ICD-10-PCS), to identify patients aged 75 years or older admitted to hospital with a primary diagnosis of ACD. Within the ACD patient group, further categorization was performed into a frail cohort, if the Hospital Frailty Risk Score was 5 or above, or a non-frail cohort, if the score was less than 5. This scoring system, developed in 2018 using electronic hospital records, classifies patients as having low risk (<5), intermediate risk (5-15), or high risk (>15), using specific ICD-10 codes, with each code assigned a corresponding point value [10]. We used a cutoff point of 5 and above to identify frailty, in order to include both intermediate and high-risk patients in the frail cohort. Patients under 75 years of age were excluded from our analysis, as this scoring system was developed and validated on patients aged 75 years and older [10]. Additional information regarding the sampling methodologies employed by the NIS can be found on the official NIS website [11]. The ICD-10 codes used in our research are listed in Supplementary Table 1. Please refer to the Hospital Frailty Risk Score for a list of ICD-10 codes included in this scoring system [10].

Outcomes of interest

Primary outcomes included a comparison of in-hospital mortality, median length of stay (LOS), and inflation-adjusted median inpatient cost between frail and non-frail patients hospitalized with ACD. Secondary outcomes included a comparison of biodemographic and hospital characteristics; local complications, such as abscess formation, intestinal perforation, intestinal obstruction, lower gastrointestinal bleeding, gastrointestinal fistula formation and paralytic ileus; as well as systemic complications, including sepsis without shock, sepsis with shock, acute kidney injury, hypovolemic/hemorrhagic shock, need for blood transfusion, acute respiratory distress syndrome, disseminated intravascular coagulation, cardiac arrest, and admission to a critical care unit. We also compared the procedures, including drainage procedures, colostomy and colectomy, between the 2 cohorts.

Statistical analysis

The analyses were performed using STATA version 17.0 (StataCorp, College Station, Texas, USA). ACD patients were stratified into frail (Hospital Frailty Risk Score ≥5) and non-frail (Hospital Frailty Risk Score ≤4) cohorts. To mitigate the inherent selection bias in this retrospective study, we decided to perform a propensity-matched analysis. A propensity score was calculated for each hospitalization, based on biodemographic and hospital characteristics, as well as a list of comorbidities detailed in Tables 1 and 2. Frail patients were then matched to non-frail patients using a 1:1 matching method within 0.05 standard deviation of the calculated propensity score, and the covariate balance was analyzed using a covariance plot before and after matching. A receiver operating characteristic (ROC) plot was generated for evaluation of the performance of age combined with frailty, versus age only, in predicting in-hospital mortality (Fig. 1). Matched cohorts were analyzed for primary and secondary outcomes using two-tailed non-parametric tests, including Pearson's chi-squared test for categorical variables and the Wilcoxon rank-sum (Mann-Whitney) test for continuous variables. The categorical variables were reported as

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Table 1 Biodemographic and hospital characteristics of acute colonic diverticulitis-related hospitalizations in the United States of America in 2016-2020 stratified by frailty status

Characteristics	Acute colonic diverticulitis					
	Unmatched cohorts			Propensity matched cohorts		
Patient and hospital characteristics	Non-frail patients	Frail patients	P-value	Non-frail patients	Frail patients	P-value
Number of hospitalizations (n)	241095 (46.7%)	275630 (53.3%)		21720	21720	
Median age, years (IQR)	81 (78-86)	83 (79-88)	<0.001	82 (78-87)	82 (78-87)	0.039
Sex			<0.001			0.580
Male	90580 (37.6%)	94155 (34.2%)		7910 (36.4%)	7965 (36.7%)	
Female	150470 (62.4%)	181445 (65.8%)		13810 (63.6%)	13755 (63.3%)	
Race			<0.001			0.800
White	182475 (77.5%)	208465 (77.4%)		16991 (78.2%)	16930 (77.9%)	
Black	25835 (11.0%)	33295 (12.4%)		2495 (11.5%)	2570 (11.8%)	
Hispanic	17955 (7.6%)	17645 (6.6%)		1359 (6.3%)	1350 (6.2%)	
Asian or Pacific Islander	3880 (1.6%)	4415 (1.6%)		400 (1.8%)	385 (1.8%)	
Others	5420 (2.3%)	5450 (2.0%)		475 (2.2%)	485 (2.2%)	
Median household income, national quartile for patient ZIP Code			<0.001			0.028
$1-$43,999	62685 (26.3%)	72665 (26.7%)		5605 (25.8%)	5535 (25.5%)	
$44,000-$55,999	61085 (25.7%)	71195 (26.1%)		5676 (26.1%)	5930 (27.3%)	
$56,000-$73,999	59750 (25.1%)	67370 (24.7%)		5380 (24.8%)	5200 (23.9%)	
$74,000 or more	54440 (22.9%)	61290 (22.5%)		5059 (23.3%)	5055 (23.3%)	
Insurance type			<0.001			0.520
Medicare	224875 (94.1%)	258340 (94.6%)		20410 (94.0%)	20350 (93.7%)	
Medicaid	1675 (0.7%)	1635 (0.6%)		135 (0.6%)	140 (0.6%)	
Private including HMO	11645 (4.9%)	12355 (4.5%)		1100 (5.1%)	1140 (5.2%)	
Others	835 (0.3%)	835 (0.3%)		75 (0.3%)	90 (0.4%)	
Median Elixhauser Comorbidity Index (IQR)	3 (2-4)	4 (3-6)	<0.001	3 (2-5)	3 (2-5)	0.884
Median hospital frailty risk score (IQR)	1.8 (0.7-3)	8 (5.6-12.3)	<0.001	2.3 (1.5-3.2)	7.2 (5.2-11.2)	<0.001
Hospital size			<0.001			0.870
Small	58435 (24.2%)	64405 (23.4%)		5495 (25.3%)	5485 (25.3%)	
Medium	75880 (31.5%)	87515 (31.8%)		6775 (31.2%)	6825 (31.4%)	
Large	106780 (44.3%)	123710 (44.9%)		9450 (43.5%)	9410 (43.3%)	
Hospital teaching status			<0.001			0.064
Non-teaching hospital	88915 (36.9%)	96360 (35.0%)		7020 (32.3%)	6840 (31.5%)	
Teaching hospital	152180 (63.1%)	179270 (65.0%)		14700 (67.7%)	14880 (68.5%)	
Region of hospital			<0.001			0.380
Northeast	52660 (21.8%)	53915 (19.6%)		4524 (20.8%)	4575 (21.1%)	
Midwest	51645 (21.4%)	64325 (23.3%)		4545 (20.9%)	4635 (21.3%)	
South	97695 (40.5%)	110700 (40.2%)		9031 (41.6%)	8855 (40.8%)	
West	39095 (16.2%)	46690 (16.9%)		3620 (16.7%)	3655 (16.8%)	

SE, standard error; IQR, interquartile range

frequency (N) and percentage (%), while continuous variables were reported as median and interquartile range (IQR). The inpatient cost was adjusted for inflation up to January 2023 using the consumer price index, in order to calculate the inflation-adjusted median inpatient cost [12]. A P-value of 0.05 or less was set as the threshold for statistical significance, and all P-values were 2-sided. The study was exempt from institutional review board approval or patient consent, as the NIS databases contain de-identified patient information and are available publicly. The study findings are reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [13].

Results

A total of 516,725 patients were identified and included in our study after application of the inclusion and exclusion criteria; of these, 241,095 (46.7%) were categorized as non-frail

Table 2 Elixhauser comorbidities among acute colonic diverticulitis-related hospitalizations in the United States in 2016-2020 stratified by frailty status

Elixhauser comorbidities	Acute colonic diverticulitis					
	Unmatched cohorts			Propensity matched cohorts		
	Non-frail patients	Frail patients	P-value	Non-frail patients	Frail patients	P-value
Number of hospitalizations (n)	241095	275630		21720	21720	
Congestive heart failure	7385 (18.4%)	14870 (27.8%)	<0.001	5010 (23.1%)	5055 (23.3%)	0.610
Cardiac arrhythmias	13875 (34.6%)	22520 (42.2%)	<0.001	8396 (38.7%)	8395 (38.7%)	0.990
Valvular disease	4265 (10.6%)	6525 (12.2%)	<0.001	2625 (12.1%)	2605 (12.0%)	0.770
Pulmonary circulation disorders	1440 (3.6%)	3600 (6.7%)	<0.001	1070 (4.9%)	1055 (4.9%)	0.740
Peripheral vascular disorders	4235 (10.6%)	7260 (13.6%)	<0.001	2720 (12.5%)	2680 (12.3%)	0.560
Hypertension, uncomplicated	22200 (55.3%)	21665 (40.6%)	<0.001	10749 (49.5%)	10585 (48.7%)	0.120
Hypertension, complicated	55 (0.1%)	360 (0.7%)	<0.001	50 (0.2%)	55 (0.3%)	0.630
Paralysis	965 (2.4%)	6050 (11.3%)	<0.001	895 (4.1%)	925 (4.3%)	0.470
Other neurological disorders	7935 (19.8%)	13635 (25.5%)	<0.001	4866 (22.4%)	4920 (22.7%)	0.540
Chronic pulmonary disease	5920 (14.8%)	5610 (10.5%)	<0.001	2865 (13.2%)	2850 (13.1%)	0.830
Diabetes, uncomplicated	4795 (12.0%)	11650 (21.8%)	<0.001	3520 (16.2%)	3510 (16.2%)	0.900
Diabetes, complicated	8485 (21.1%)	13215 (24.7%)	<0.001	4961 (22.8%)	5070 (23.3%)	0.210
Hypothyroidism	6480 (16.2%)	20305 (38.0%)	<0.001	5576 (25.7%)	5645 (26.0%)	0.450
Renal failure	1335 (3.3%)	2385 (4.5%)	<0.001	840 (3.9%)	810 (3.7%)	0.450
Liver disease	510 (1.3%)	1010 (1.9%)	<0.001	385 (1.8%)	355 (1.6%)	0.270
Peptic ulcer disease excluding bleeding	10 (<1%)	5 (<1%)	0.063	0 (0%)	0 (0%)	-
AIDS/HIV	380 (0.9%)	765 (1.4%)	<0.001	225 (1.0%)	240 (1.1%)	0.480
Lymphoma	675 (1.7%)	1110 (2.1%)	<0.001	380 (1.7%)	400 (1.8%)	0.470
Metastatic cancer	1730 (4.3%)	2935 (5.5%)	<0.001	1045 (4.8%)	1055 (4.9%)	0.820
Solid tumor without metastasis	1685 (4.2%)	2560 (4.8%)	<0.001	935 (4.3%)	940 (4.3%)	0.910
Rheumatoid arthritis/collagen vascular diseases	2780 (6.9%)	5585 (10.5%)	<0.001	1920 (8.8%)	1865 (8.6%)	0.350
Coagulopathy	4625 (11.5%)	6665 (12.5%)	<0.001	2540 (11.7%)	2570 (11.8%)	0.660
Obesity	1735 (4.3%)	5580 (10.4%)	<0.001	1350 (6.2%)	1270 (5.8%)	0.110
Weight loss	4670 (11.6%)	29135 (54.5%)	<0.001	4414 (20.3%)	4485 (20.6%)	0.400
Fluid and electrolyte disorders	1260 (3.1%)	1820 (3.4%)	0.024	755 (3.5%)	745 (3.4%)	0.790
Blood loss anemia	2080 (5.2%)	4035 (7.6%)	<0.001	1425 (6.6%)	1390 (6.4%)	0.500
Deficiency anemia	370 (0.9%)	780 (1.5%)	<0.001	250 (1.2%)	250 (1.2%)	1.000
Alcohol abuse	175 (0.4%)	305 (0.6%)	0.004	70 (0.3%)	90 (0.4%)	0.110
Drug abuse	70 (0.2%)	210 (0.4%)	<0.001	55 (0.3%)	25 (0.1%)	<0.001
Psychoses	3340 (8.3%)	7850 (14.7%)	<0.001	2450 (11.3%)	2380 (11.0%)	0.290
Depression	10355 (25.8%)	24845 (46.5%)	<0.001	7716 (35.5%)	7770 (35.8%)	0.590

and 275,630 (53.3%) as frail patients, as detailed above. Frail patients were older, and presented a higher burden of comorbidities as indicated by their higher Elixhauser Comorbidity Index. The majority of patients in both cohorts were white females, hospitalized in large teaching hospitals in the southern USA (Table 1).

Our matching process resulted in no significant differences in biodemographics, hospital characteristics or major comorbidities among the matched cohorts, as indicated by a P-value >0.05 (Table 1 and Table 2). The difference in median hospital frailty risk score between the 2 cohorts remained statistically significant after matching (7.2 vs. 2.3, P<0.001), as the matching process was

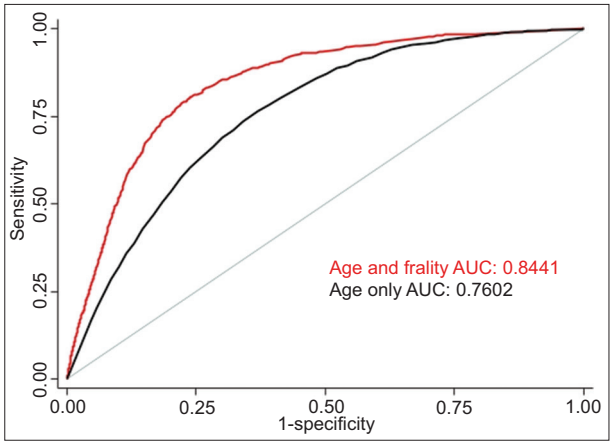

Figure 1 ROC plots for age and frailty combined (red) vs. age only (black) as primary predictors of in-hospital mortality ROC, receiver operating characteristic; AUC, area under the curve

performed after the initial patient stratification. The ROC plot showed a better prediction of in-hospital mortality using age and frailty combined compared to age alone (Fig. 1). Matched frail patients showed significantly greater in-hospital mortality (1.1% vs. 0.2%, P<0.001), median LOS (4 days vs. 3 days, P<0.001) and inflation-adjusted median inpatient cost (10442 vs. 9028 USD, P<0.001) compared to their non-frail counterparts. Frailty in ACD was also significantly associated with higher rates of complications, including abscess formation, intestinal perforation, gastrointestinal fistula formation, sepsis without shock, sepsis with shock, acute kidney injury, hypovolemic or hemorrhagic shock, need for blood transfusion, cardiac arrest, and need for intensive care (all P-values <0.001). However, frail patients experienced less frequent gastrointestinal bleeding compared to non-frail patients.

There were also noteworthy differences between the two cohorts in the need for colectomy and colostomy. The frail ACD cohort exhibited a higher prevalence of open colectomy and colostomy (both P-values <0.001), whereas the rate of laparoscopic colectomy was lower in frail patients compared to their matched counterparts (P<0.001) (Table 3).

Discussion

Diverticular disorder is a common condition, and its prevalence increases with advancing age. The impact of age is particularly evident, with rates ranging from 10% among individuals under 40 years of age to a staggering 66% among those aged 80 and above [14]. Approximately 10-25% of individuals with diverticular disease will eventually experience ACD [1]. Given the growth of the aging population, it is anticipated that the incidence of ACD will continue to rise [15]. Numerous published studies have investigated the relationship between age and outcomes related to ACD [15-18]. In our research, we investigated the impact of frailty on elderly patients hospitalized with ACD; to the best of our knowledge, no previous studies have investigated this.

Frailty is closely linked to the aging process and is characterized by an increased vulnerability to stress. This vulnerability, in turn, elevates the risks of adverse outcomes such as sickness, falls, hospitalization, delirium and disability, as well as mortality. Therefore, it is a significant concern in terms of susceptibility to poor outcomes [5,6,19]. Frailty does not have a single etiology; rather, it is a product of an imbalance in the intricate interactions between the body's different physiological systems, contributing to compromised homeostasis [5]. The observation that a subset of frail patients lacks significant comorbidities suggests that these imbalances can result either from age-related decline, such as age-related anorexia or loss of muscle mass, or as a consequence of comorbidities [5]. In our effort to contribute to the ongoing discussion, we present a comprehensive 5-year analysis based on the NIS database, shedding light on clinical outcomes among both frail and non-frail patients with ACD. We used the Hospital Frailty Risk Score for our analysis, as, like the NIS database, it uses ICD-10 codes and aligns closely with our methodology.

Based on the Hospital Frailty Risk Score, the prevalence of frailty in our study population was found to be over 50%. The prevalence of frailty varies depending on the assessment method used. While previous studies that included patients older than 65-70 years reported a prevalence between 4% and 16.3%, our patient population exhibited a significantly higher prevalence [20-22]. The patients in our study were older than the patients included in the aforementioned studies, as we specified a minimum age of 75 years as an inclusion criterion. However, the high frailty prevalence of over 50% in our study patients might still suggest that elderly patients with ACD are at particularly higher risk, and should receive more tailored care to prevent adverse in-hospital outcomes.

The other notable findings of our study are a higher in-hospital mortality, a longer LOS, and a higher inpatient cost associated with frailty status. Additionally, frail patients experienced a higher risk of local and systemic complications of ACD requiring admission to critical care units, and a greater need for inpatient laparoscopic and open colectomy or colostomy procedures. This indicates a greater severity of ACD in frail patients compared to their propensity score-matched non-frail counterparts. When we compared age combined with frailty to age alone, age combined with frailty was better at predicting in-hospital mortality, as indicated by the area under the ROC curve (Fig. 1). Numerous published articles report age as an independent factor for elevated mortality and complications in ACD patients [15-18]. As far as we are aware, no published article currently available investigates frailty as an independent factor within this context.

This study, based on the NIS database, possesses both strengths and limitations. An important strength lies in its large sample size, which adds to the statistical power and generalizability of the study findings. Furthermore, the NIS database provides a comprehensive dataset, including patient demographics, diagnoses and procedures, allowing analysis of various variables in depth. A limitation is that the retrospective

Table 3 Primary and secondary outcomes of acute colonic diverticulitis-related hospitalizations in the United States in 2016-2020 stratified by frailty status

Outcomes	Acute colonic diverticulitis					
	Unmatched cohorts			Propensity matched cohorts		
	Non-frail patients	Frail patients	P-value	Non-frail patients	Frail patients	P-value
Number of hospitalizations	241095 (46.7%)	275630 (53.3%)		21,720	21,720	
In-hospital mortality	765 (0.3%)	5360 (1.9%)	<0.001	45 (0.2%)	245 (1.1%)	<0.001
Median LOS, days (IQR)	3 (2-5)	4 (3-7)	<0.001	3 (2-5)	4 (2-6)	<0.001
Median inpatient cost, USD (IQR)	8119 (5430-13394)	10508 (6770-18282)	<0.001	9028 (5991-14868)	10442 (6847-17774)	<0.001
Local complications						
Abscess	32950 (13.7%)	41895 (15.2%)	<0.001	2991 (13.8%)	3361 (15.5%)	<0.001
Perforation	32845 (13.6%)	41680 (15.1%)	<0.001	2971 (13.7%)	3336 (15.4%)	<0.001
Bleeding	121155 (50.3%)	135325 (49.1%)	<0.001	12348 (56.9%)	11559 (53.2%)	<0.001
Obstruction	3405 (1.4%)	4135 (1.5%)	0.009	490 (2.3%)	490 (2.3%)	1.000
Fistula	6480 (2.7%)	8455 (3.1%)	<0.001	628 (2.9%)	835 (3.8%)	<0.001
Paralytic ileus	280 (0.1%)	625 (0.2%)	<0.001	25 (0.1%)	30 (0.1%)	0.500
Systemic complications						
Sepsis without shock	210 (0.1%)	2425 (0.9%)	<0.001	20 (0.1%)	150 (0.7%)	<0.001
Sepsis with shock	65 (<1%)	3050 (1.1%)	<0.001	10 (0.05%)	165 (0.8%)	<0.001
Acute kidney injury	11960 (5.0%)	80140 (29.1%)	<0.001	1340 (6.2%)	5580 (25.7%)	<0.001
Hypovolemic/hemorrhagic shock	1375 (0.6%)	3715 (1.3%)	<0.001	135 (0.6%)	210 (1.0%)	<0.001
Blood transfusion	33480 (13.9%)	50935 (18.5%)	<0.001	3511 (16.2%)	3826 (17.6%)	<0.001
ARDS	10 (<1%)	165 (0.1%)	<0.001	0 (0.0%)	10 (<1%)	0.002
DIC	35 (<1%)	245 (0.1%)	<0.001	0 (0.0%)	5 (<1%)	0.025
Cardiac arrest	745 (0.3%)	1790 (0.6%)	<0.001	70 (0.3%)	120 (0.6%)	<0.001
Admission to critical care unit	385 (0.2%)	3565 (1.3%)	<0.001	15 (0.1%)	120 (0.6%)	<0.001
Colectomy						
Laparoscopic	33190 (13.8%)	28655 (10.4%)	<0.001	3432 (15.8%)	2714 (12.5%)	<0.001
Robotic	585 (0.2%)	280 (0.1%)	<0.001	45 (0.2%)	30 (0.1%)	0.083
Open	13980 (5.8%)	19415 (7.0%)	<0.001	1162 (5.3%)	1263 (5.8%)	0.035
Colostomy	110 (<1%)	265 (0.1%)	<0.001	60 (0.2%)	85 (0.4%)	0.038

LOS, length of stay; IQR, interquartile range; ARDS, acute respiratory distress syndrome; DIC, disseminated intravascular coagulation

nature of the study may have introduced selection bias and limited the ability to establish causal relationships. However, the propensity-matched technique was used to eliminate these biases and unmeasured confounders. Additionally, the reliance on administrative codes for diagnoses and procedures within the NIS database could potentially lead to inaccuracies and misclassifications [23]. NIS also lacks detailed clinical information regarding vital signs, laboratory results and longitudinal follow up [24]. Despite these limitations, the study offers valuable insights into the subject matter, which can be further explored and substantiated through additional research.

In summary, this study found that frailty contributes independently to adverse inpatient outcomes related to ACD in the elderly, including higher mortality rates, prolonged hospital stays, greater healthcare costs, and higher complication rates. While age remains an important factor, frailty emerges as a distinct and substantial determinant of patient outcomes. These findings underscore the importance of factoring in frailty when clinically managing elderly ACD patients, and offer valuable insights for future research and interventions aimed at improving the care and outcomes of this vulnerable population.

Summary Box

What is already known:

- Acute colonic diverticulitis is a common condition, with significant healthcare resource utilization
- Acute colonic diverticulitis preferentially affects older patients
- Frailty is known to independently predict mortality in the elderly

What the new findings are:

- Frailty is highly prevalent in elderly patients with acute colonic diverticulitis
- Frail patients with acute colonic diverticulitis had higher in-hospital mortality and healthcare resource utilization, and greater local and systemic complications
- In acute colonic diverticulitis, frailty combined with age was found to be a better predictor of mortality compared to age alone

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Supplementary material

Supplementary Table 1 International classification of diseases, tenth revision, clinical modification (ICD-10) codes used in the present study

Acute colonic diverticulitis	K5700 K5701 K5710 K5711 K5712 K5713 K5720 K5721 K5730 K5731 K5732 K5733 K5740 K5741 K5750 K5751 K5752 K5753 K5780 K5781 K5790 K5791 K5792 K5793
Abscess	K651 K6811 K6812 K6819 K51514 K630 K6811 K6819 K5720 K5721 K5740 K5741 K5780 K5781
Intestinal perforation	K631 P780 K5720 K5721 K5740 K5741 K5780 K5781
Diverticulitis with bleeding	K5721 K5731 K5733 K5741 K5751 K5753 K5781 K5791 K5793
Intestinal obstruction	K50012 K50112 K50812 K50912 K51012 K51212 K51312 K51412 K51512 K51812 K51912 K56600 K56601 K56609 K56690 K56691 K56699 K9130 K9131 K9132
Gastrointestinal fistula	K51913 K603 K604 K605 K632 N321 N822 N823 N824
Paralytic ileus	K560
Sepsis without shock	R6520
Sepsis with shock	R6521
Acute kidney injury	N170 N171 N172 N178 N179
Hypovolemic/hemorrhagic shock	R571
Blood transfusion	30230H1 30230N1 30233N1 30240H1 30240N1 30243H1 30243N1
ARDS	J80
DIC	D65
Cardiac arrest	I462 I468 I469 I97120 I97121 Z8674
Percutaneous drainage	0D9E30Z 0D9E3ZX 0D9E3ZZ 0D9F30Z 0D9F3ZX 0D9F3ZZ 0D9G30Z 0D9G3ZX 0D9G3ZZ 0D9H30Z 0D9H3ZX 0D9H3ZZ 0D9K30Z 0D9K3ZX 0D9K3ZZ 0D9L30Z 0D9L3ZX 0D9L3ZZ 0D9M30Z 0D9M3ZX 0D9M3ZZ 0D9N30Z 0D9N3ZX 0D9N3ZZ 8E0WXBG 8E0WXBH
Laparoscopic drainage	0D9E40Z 0D9E4ZX 0D9E4ZZ 0D9E80Z 0D9E8ZX 0D9E8ZZ 0D9F40Z 0D9F4ZX 0D9F4ZZ 0D9F80Z 0D9F8ZX 0D9F8ZZ 0D9G40Z 0D9G4ZX 0D9G4ZZ 0D9G80Z 0D9G8ZX 0D9G8ZZ 0D9H40Z 0D9H4ZX 0D9H4ZZ 0D9H80Z 0D9H8ZX 0D9H8ZZ 0D9K40Z 0D9K4ZX 0D9K4ZZ 0D9K80Z 0D9K8ZX 0D9K8ZZ 0D9L40Z 0D9L4ZX 0D9L4ZZ 0D9L80Z 0D9L8ZX 0D9L8ZZ 0D9M40Z 0D9M4ZX 0D9M4ZZ 0D9M80Z 0D9M8ZX 0D9M8ZZ 0D9N40Z 0D9N4ZX 0D9N4ZZ 0D9N80Z 0D9N8ZX 0D9N8ZZ
Open drainage	0D9E0ZX 0D9E0ZZ 0D9F0ZX 0D9F0ZZ 0D9G0ZX 0D9G0ZZ 0D9H0ZX 0D9H0ZZ 0D9K0ZX 0D9K0ZZ 0D9L0ZX 0D9L0ZZ 0D9M0ZX 0D9M0ZZ 0D9N0ZX 0D9N0ZZ
Colostomy	0D1E074 0D1E0J4 0D1E0Z4 0D1E474 0D1E4J4 0D1E4K4 0D1E4Z4 0D1E874 0D1E8J4 0D1E8K4 0D1E8Z4
Laparoscopic colectomy	0DBE4ZX 0DBE4ZZ 0DBE8ZX 0DBE8ZZ 0DBF4ZX 0DBF4ZZ 0DBF8ZX 0DBF8ZZ 0DBG4ZX 0DBG4ZZ 0DBG8ZX 0DBG8ZZ 0DBGFZZ 0DBH4ZX 0DBH4ZZ 0DBH8ZX 0DBH8ZZ 0DBK4ZX 0DBK4ZZ 0DBK8ZX 0DBK8ZZ 0DBL4ZX 0DBL4ZZ 0DBL8ZX 0DBL8ZZ 0DBLFZZ 0DBM4ZX 0DBM4ZZ 0DBM8ZX 0DBM8ZZ 0DBMFZZ 0DBN4ZX 0DBN4ZZ 0DBN8ZX 0DBN8ZZ 0DBNFZZ 0DTE8ZZ 0DTE4ZZ 0DTF4ZZ 0DTF8ZZ 0DTG4ZZ 0DTG8ZZ 0DTGFZZ 0DTH4ZZ 0DTH8ZZ 0DTK4ZZ 0DTK8ZZ 0DTL4ZZ 0DTL8ZZ 0DTLFZZ 0DTM4ZZ 0DTM8ZZ 0DTMFZZ 0DTN4ZZ 0DTN8ZZ 0DTNFZZ
Robotic colectomy	8E0W0CZ 8E0W3CZ 8E0W7CZ 8E0WXBZ 8E0WXCZ
Open colectomy	0DBE0ZX 0DBE0ZZ 0DBF0ZX 0DBF0ZZ 0DBG0ZX 0DBG0ZZ 0DBH0ZX 0DBH0ZZ 0DBK0ZX 0DBK0ZZ 0DBL0ZX 0DBL0ZZ 0DBM0ZX 0DBM0ZZ 0DBN0ZX 0DBN0ZZ 0DTE0ZZ 0DTF0ZZ 0DTG0ZZ 0DTH0ZZ 0DTK0ZZ 0DTL0ZZ 0DTM0ZZ 0DTN0ZZ