Nonelective Excisional Colorectal Surgery in English National Health Service Trusts: A Study of Outcomes from Hospital Episode Statistics Data between 1996 and 2007

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BACKGROUND: Nonelective colorectal surgery is associated with substantial patient morbidity and mortality. This study sought to describe the practice of emergency colorectal surgery in the United Kingdom during an 11-year period using the Hospital Episode Statistics (HES) database.

STUDY DESIGN: All nonelective admissions in patients undergoing 1 of 8 colorectal resectional procedures between 1996 and 2007 were included. Time trends, univariate, and multivariate mortality and length of stay outcomes were analyzed.

RESULTS: A total of 102,236 major urgent/emergency procedures were performed in English National Health Service Trusts between April 1996 and March 2007. Thirty-day in-hospital postoperative mortality rates in patients with colorectal cancer and diverticular disease were 13.3% and 15.4%, respectively. The corresponding 1-year postoperative mortality was 34.7% and 22.6%. On multivariate analysis, benign diagnosis, advanced age, high comorbidity score, social deprivation, and specific procedure types were independent predictors of early and 1-year postoperative mortality ($p < 0.001$). Independent risk factors for extended hospital stay were advanced age, social deprivation, distal (compared with proximal) bowel resection, and a diagnosis of ulcerative colitis ($p < 0.001$).

CONCLUSIONS: HES data suggest that in everyday practice, postoperative mortality among patients undergoing nonelective admission followed by colorectal resection is high. Additional investigation is required to assess the reliability of HES data for monitoring institutional variation in this context.
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Emergency colorectal surgery is associated with substantial morbidity and mortality and often poses a management challenge to the treating surgeon.[1] Importantly, emergency presentation represents an independent predictor of poor outcomes when compared with case-matched controls undergoing elective colorectal surgery.[1,2]

The United Kingdom Hospital Episode Statistics (HES) database is an administrative record of all admissions to English National Health Service (NHS) hospitals.[3] It has recently been compared with a national clinical colorectal dataset, ie, the Association of Coloproctology of Great Britain and Ireland database,[4,5] for procedures carried out for colorectal cancer. Discrepancies in crude mortality recording between the HES and Association of Coloproctology of Great Britain and Ireland data for certain elective procedures were small.[4] Overall, this routinely collected administrative dataset has demonstrated similar discrimination for mortality risk prediction to the Association of Coloproctology of Great Britain and Ireland database.[4,5] Validation of the HES dataset against clinical databases for benign colorectal conditions has not been carried out.

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Abbreviations and Acronyms

DD = diverticular disease
HES = Hospital Episode Statistics
IBD = inflammatory bowel disease
NHS = National Health Service
OPCS-4 = Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures, 4th revision
UC = ulcerative colitis

This study aims to describe the temporal trends in the practice of emergency colonic and rectal surgery in the United Kingdom during and 11-year period using the HES database. In addition, we sought to evaluate early and 1-year mortality rates and length of stay after emergency surgery.

METHODS

HES

The HES database has been described in detail previously.[8] In brief it is an administrative record system that includes all patients admitted to National Health Service hospitals in England. HES data permit only identification of the consultant team that looked after patients. They do not permit identification of the grade of surgeon who carried out the actual procedure. Each record contains patient level demographic, diagnostic and operative data.

Each record contains a primary and up to 13 secondary diagnoses, categorized according to the ICD-10, and up to 12 procedure fields coded using the Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures, 4th revision (OPCS-4).We used the secondary diagnosis codes to create the Charlson comorbidity index.[6] An attempt was not made to distinguish between new and old comorbidities from secondary diagnostic codes due to uncertainty regarding the reliability of this method. The Carstairs index of deprivation is a small-area deprivation score that we linked to HES according to patient postcode.[7]

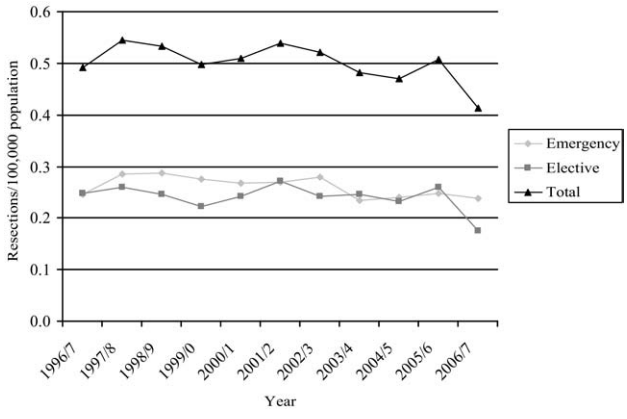

Figure 2. Time trends in subtotal colectomy and ileostomy (Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures, 4th revision [OPCS-4] subcodes H05.2 and H05.3) for ulcerative colitis (UC) between 1996/7 and 2006/7. The resection rate is normalized to the mid-year population estimates for England (taken from Office of National Statistics data).

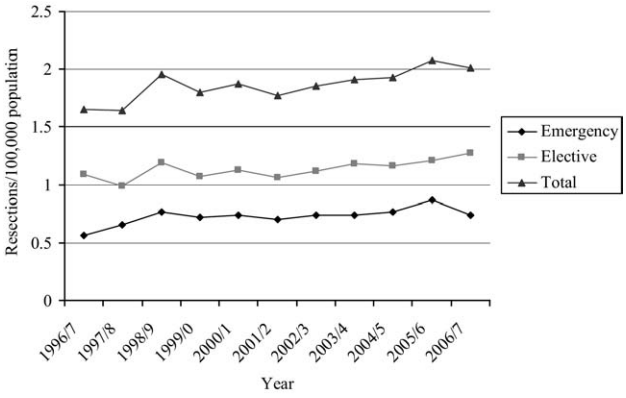

Figure 1. Time trends in emergency right hemicolectomy (Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures, 4th revision [OPCS-4] 3-digit code H07) for Crohn disease between 1996/7 and 2006/7. The resection rate is normalized to the mid-year population estimates for England (taken from Office of National Statistics data).

Database inclusions and variable recoding

Procedures that took place during an admission spell that was classified as nonelective were included. Nonelective operative admissions were supplemented with elective operative admissions for Figures 1 and 2 to provide trends for inflammatory bowel disease (IBD) procedures over time. OPCS-4 codes were put into individual operation categories. The major colorectal resections included, and their corresponding OPCS-4 codes, are described in Table 1. Distal bowel resections comprised left hemicolectomy, sigmoid colectomy, total colectomy, Hartmann, and rectal excision procedures. The Hartmann procedure rate was considered as the annual proportion of Hartmann procedures (H33.5) compared with total distal bowel resections.

Individual diagnoses were recoded into major diagnostic categories, ie, malignancy, diverticular disease (DD), and IBD. The following ICD-10 codes were used to define diagnostic groups: inflammatory bowel disease, 3-digit ICD-10 codes: K50−Crohn disease + K51−ulcerative colitis; diverticular disease, 3-digit ICD-10 code: K57−diverticular disease; malignancy, 3-digit ICD-10 codes: C18−malignant neoplasm of colon + C19−malignant neoplasm of rectosigmoid junction + C20−malignant neoplasm of rectum + C21−malignant neoplasm of anus and anal canal.

Table 1. Frequency of 3-Digit and 4-Digit OPCS-4 Codes Relating to Emergency Colonic and Rectal Procedures Carried Out in English National Health Service Trusts between April 1, 1996, and March 31, 2007

OPCS-4 codes—procedure description	Malignancy		Diverticular disease		Crohn disease		Ulcerative colitis		Obstruction or ileus		Vascular disorders		Peritonitis	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
H07—right hemicolectomy	15,861	39.8	1,450	7.3	3,962	76.9	93	4.4	3,514	42.6	1,859	53.7	551	29.8
H08, H06—transverse and extended right hemicolectomy	6,179	15.5	187	0.9	329	6.4	35	1.7	500	6.1	383	11.1	104	5.6
H09—left hemicolectomy	3,041	7.6	717	3.6	129	2.5	28	1.3	274	3.3	299	8.6	73	3.9
H10—sigmoid colectomy	4,343	10.9	3,868	19.5	118	2.2	97	4.6	2,047	24.8	180	5.2	167	9
H05—total colectomy	917	2.3	333	1.7	292	5.7	1420	67.7	203	2.5	304	8.8	70	3.8
H33.5—Hartmann procedure*	7,250	18.2	12,385	62.3	130	2.5	42	2	1,370	16.6	342	9.9	835	45.1
H33.2, H33.3, H33.4, H33.6, H33.8, H33.9—rectal excision†	2,156	5.4	923	4.6	67	1.3	60	2.9	334	4	84	2.4	51	2.8
H04.1—panproctocolectomy and ileostomy	77	0.2	11	0.1	125	2.4	322	15.4	5	0.1	13	0.4	1	0.1
Total	39,824	100.0	19,874	100.0	5,152	100.0	2,097	100.0	8,247	100.0	3,464	100.0	1,852	100.0

*H33.5—excision of rectum, rectosigmoidectomy, and closure of rectal stump and exteriorization of bowel.
†Rectal excision procedures (operations were combined into a single group of rectal excision procedures including procedures codes: H33.2 + H33.3 + H33.4 + H33.6 + H33.8 + H33.9). The latter codes include: 4-digit OPCS-4 codes H33.2—excision of rectum, proctectomy, and anastomosis of colon to anus + H33.3—excision of rectum, anterior resection of rectum, and anastomosis of colon to rectum using staples + H33.4—excision of rectum, anterior resection of rectum, and anastomosis + H33.6—excision of rectum, anterior resection of rectum, and exteriorization of bowel + H33.8—excision of rectum, Other specified + H33.9—excision of rectum, unspecified.
OPCS-4, Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures, 4th revision.

Other diagnostic categories included paralytic ileus and intestinal obstruction without hernia, 3-digit ICD-10 code: K56—vascular disorders of intestine, 3-digit ICD-10 code: K55, and peritonitis, 3-digit ICD-10 code: K65.

We grouped age into 4 clinically relevant categories: younger than 55 years, 55 to 69 years, 70 to 79 years, and older than 79 years. Use of laparoscopy for a given procedure during the study years was denoted using the Y50.8 code as a secondary code after a primary OPCS-4 procedure code. For example, a left hemicolectomy performed with laparoscopic assistance would be described on the database according to an H09 primary code and a Y50.8 secondary code. Only 10 years of data (between April 1996/7 and April 2005/6) were used for analyses that included laparoscopic procedures because of a coding change that occurred on April 1, 2006.

Outcomes variables

Thirty-day in-hospital mortality and 365-day all-cause mortality were the mortality outcomes measures. Three-hundred and sixty-five—day mortality figures were not available in the data until 2000. A delay exists between late death and this information being recorded onto the HES database. For these reasons, only data relating to the period between April 1, 2000, and March 31, 2005, were used to determine 365-day mortality rates. Data from all study years were used to calculate 30-day in-hospital mortality rates.

Length of stay describes the time (in days) that a patient spent as an inpatient during their index admission. Readmissions were considered to be subsequent emergency admissions within 28 days of the date of discharge after their original procedure. Both mean (±SD) and median (interquartile range) lengths of hospital stay are described in unadjusted comparisons.

Statistical methodology

Categorical variables were investigated using the chi-square test. Logistic regression models were constructed to evaluate the independent role of operative technique (ie, laparoscopic or open), primary diagnosis, operation type, age, gender, comorbidity, and social deprivation on 30-day and 365-day mortality. Regression models that investigated 30-day mortality rates and duration of hospital stay excluded data from the last study year (ie, April 1, 2006, to March 31, 2007) as laparoscopic approach was included as a model covariate. The regression model investigating predictors of 365-day mortality employed data between April 1, 2000, and March 31, 2005. A multiple linear regression model was constructed to evaluate the role of operative technique (ie, laparoscopic versus open), primary diagnosis, operation type, age, gender, comorbidity, and social

deprivation on the natural logarithm of length of stay, as the length of stay approximately followed a log-normal distribution. Statistical analyses were carried out using SPSS Version 16.0 (SPSS Inc). For tests of significance, p values <0.05 were considered significant.

RESULTS

Between April 1, 1996, and March 31, 2007, there were 102,236 emergency major colonic and rectal emergency procedures performed in English NHS hospitals. Of these, 39.0% (n = 39,824) were assigned an ICD-10 diagnostic code denoting a colorectal malignancy, 19.4% (n = 19,874) were coded to DD and 7.1% (n = 7,249) to IBD. Other ICD-10 diagnostic codes frequently assigned within this emergency colorectal category included: K56 (3-digit ICD-10 code: paralytic ileus and intestinal obstruction without hernia; n = 8,247 [8.1%]), K55 (3-digit ICD-10 code: vascular disorders of intestine; n = 3,464 [3.4%]), K65 (3-digit ICD-10 code: peritonitis; n = 1,852 [1.8%]). An additional 21,726 (21.3%) cases were coded to an additional 499 diagnostic codes (Table 1); 41.8% (9,080 of 21,726) and 24.7% (5,365 of 21,726) of the latter unspecified ("other") diagnostic category were coded to right hemicolectomy and Hartmann procedure categories, respectively.

Between April 1, 1996, and March 31, 2007, the principal operations carried out in patients with a diagnosis of colorectal malignancy were right hemicolectomies and Hartmann procedures (Table 1). In contrast, the most frequently performed emergency procedures in patients with a diagnosis of DD were Hartmann procedure and sigmoid colectomy (Table 1); 76.9% (3.962 of 5,152) of patients who underwent 1 of 8 emergency colorectal procedures listed here (Table 1) for Crohn disease were assigned to the H07 OPCS-4 right hemicolectomy code. In contrast, 67.7% (1,420 of 2,097) of all emergency colorectal procedures carried out for ulcerative colitis (UC) were assigned to the H05 3-digit total colectomy code, of which subtotal colectomy and ileostomy (4-digit OPCS subcodes H05.2 and H05.3) comprise nearly all cases (92.2%; 1,309 of 1,420). An additional 15.4% (322 of 2,097) of emergency cases carried out for UC represented proctocolectomy and ileostomy procedures. The demographics of patients undergoing emergency major colorectal surgery between the study dates are described according to diagnostic group in Table 2.

Mortality after emergency colorectal surgery

Unadjusted 30-day in-hospital and 365-day mortality rates are described according to underlying diagnosis in Table 3. Results of a logistic regression analysis investigating factors that predict for 30-day and 365-day postoperative mortality after emergency colorectal surgery are described in Table 4. Advanced age, high comorbidity score, social deprivation, and specific procedures were strong independent predictors of early and 1-year mortality after emergency surgery (all $p < 0.001$). Patients with a malignant diagnosis were less likely to die within 30 days and 365 days of their operation than those with DD ($p < 0.001$) once corrected for other variables in multivariate analyses (Table 4).

Among patients who were operated on as emergencies between April 2000 and March 2005 with colorectal cancer, 1-year mortality was 35.8% (1,736 of 4,844) and 46.8% (1,808 of 3,866) for patients aged between 70 and 79 years and older than 80 years, respectively. Similarly, between April 1996 and March 2007, 34.7% (1,302 of 3,749) of patients undergoing emergency operations with DD and aged older than 80 years died in hospital within 30 days of their operation. Overall, 30-day mortality was highest for DD patients undergoing a procedure assigned to the total colectomy code (26.1%, 87 of 333) or Hartmann procedure code (17.3%; 2,139 of 12,385). More than one-third (37.2%; 923 of 2,482) of patients aged older than 80 years undergoing an emergency Hartmann procedure for DD died in hospital within 30 days of operation.

The 30-day in-hospital mortality of all patients undergoing an emergency subtotal colectomy and ileostomy (4-digit OPCS-4 subcodes: H05.2 and H05.3) for UC was 4.7% (61 of 1,309). The age-specific mortality for patients aged between 70 and 79 years and older than 80 years was 19.0% (22 of 116) and 38.2% (13 of 34), respectively. The 30-day mortality of patients undergoing H07 3-digit OPCS-4 right hemicolectomy code for Crohn disease was 1.6% (65 of 3,692). The number of elderly patients (older than 70 years) requiring emergency surgery in this group was small but also associated with substantial 30-day mortality risk (14.2%; 35 of 247). The unadjusted 30-day mortality of patients assigned to ICD-10 codes K56 (paralytic ileus and intestinal obstruction without hernia) and K65 (peritonitis) in patients aged 80 years or older was 27.6% (524 of 1,898) and 62.2% (232 of 373), respectively. Results of a multivariate logistic regression analysis investigating mortality after emergency colorectal surgery are described in Table 4.

Length of stay after emergency colorectal surgery

Table 3 describes the median length of stay and 4-week readmission rates for patients undergoing an emergency colorectal procedure, subdivided according to diagnostic category. Median length of stay for patients undergoing subtotal colectomy and ileostomy (4-digit OPCS-4 subcodes H05.2 and H05.3) for UC was 22 (interquartile

Table 2. Descriptive Characteristics of Patients Undergoing Emergency Colonic or Rectal Operation between April 1996 and March 2007

	Malignancy		Diverticular disease		Crohn disease		Ulcerative colitis		Obstruction or paralytic ileus		Vascular disorder		Peritonitis	
Characteristic	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Gender														
Male	19,624	49.3	8,148	41.0	2,273	44.1	1,117	53.3	3,862	46.8	1,458	42.1	767	41.4
Female	20,200	50.7	11,726	59.0	2,879	55.9	980	46.7	4,385	53.2	2,006	57.9	1,085	58.6
Total	39,824	100.0	19,874	100.0	5,152	100.0	2,097	100	8,247	100.0	3,464	100	1,852	100.0
Age, y														
Younger than 55	3,711	9.3	4,196	21.1	3,968	77.0	1,276	60.8	2,211	26.8	543	15.7	457	24.7
55-69	11,473	28.8	5,955	30.0	759	14.7	500	23.8	1,962	23.8	961	27.7	491	26.5
70-79	13,622	34.2	5,974	30.1	316	6.1	242	11.5	2,176	26.4	1,151	33.2	531	28.7
Older than 79	11,018	27.7	3,749	18.9	109	2.1	79	3.8	1,898	23.0	809	23.4	373	20.1
Total	39,824	100.0	19,874	100.0	5,152	100.0	2,097	100	8,247	100.0	3,464	100	1,852	100.0
Charlson comorbidity score														
0	1,602	4.0	14,692	73.9	4,700	91.2	1,833	87.4	6,204	75.2	2,075	59.9	1,244	67.2
1	319	0.8	3,183	16.0	364	7.1	203	9.7	1,060	12.9	780	22.5	234	12.6
2	2,0196	50.7	1,197	6.0	65	1.3	43	2.1	581	7.0	356	10.3	230	12.4
3	3,803	9.5	410	2.1	9	0.2	14	0.7	177	2.1	153	4.4	68	3.7
4	777	2.0	117	0.6	8	0.2	2	0.1	52	0.6	42	1.2	21	1.1
5	10,745	27.0	203	1.0	6	0.1	2	0.1	136	1.6	39	1.1	42	2.3
≥6	2,382	6.0	72	0.4	—		—		37	0.4	19	0.5	13	0.7
Total	39,824	100.0	19,874	100.0	5,152	100.0	2,097	100	8,247	100.0	3,464	100	1,852	100.0
Carstairs deprivation index														
1 Least deprived	6,908	17.3	3,354	16.9	828	16.1	436	20.8	1,540	18.7	504	14.5	280	15.1
2	8,348	21.0	4,053	20.4	1,052	20.4	458	21.8	1,812	22.0	632	18.2	357	19.3
3	8,600	21.6	4,358	21.9	1,054	20.5	460	21.9	1,677	20.3	699	20.2	400	21.6
4	8,432	21.2	4,266	21.5	1,135	22.0	414	19.7	1,611	19.5	794	22.9	398	21.5
5 Most deprived	7,246	18.2	3,686	18.5	1,046	20.3	314	15	1,527	18.5	804	23.2	406	21.9
Unclassified	290	0.7	157	0.8	37	0.7	15	0.7	80	1.0	31	0.9	11	0.6
Total	39,824	100.0	19,874	100.0	5,152	100.0	2,097	100	8,247	100.0	3,464	100	1,852	100.0

range 16 to 23; n = 1,309) days. Then 14.1% (184 of 1,309) of these patients were subsequently readmitted after discharge within 28 days. Thirty-nine percent (510 of 1,309) of all patients within this patient group had also been admitted as emergencies more than once in the 12 months before operation. Median length of stay for patients undergoing emergency right hemicolectomy for Crohn disease was 13 (interquartile range 9 to 20; n = 3,962) days. The 28-day readmission rate and 12-month prior emergency admission rates were 12.4% (490 of 3,962) and 43.5% (1,725 of 3,962), respectively, for patients with Crohn disease who ultimately required an emergency right hemicolectomy.

Table 5 describes the results of a multiple linear regression analysis of study covariates on length of stay (log-transformed for analysis and back-exponentiated for presentation). The independent impact of increasing age, female gender, social deprivation, left-sided and rectal resections (compared with right-sided resections), and a diagnosis of UC (compared with a diagnosis of colorectal malignancy) on longer hospital stay is demonstrated. A clear relationship between increasing patient comorbidity and length of stay was not observed.

Operative trends in emergency colorectal surgery between 1996/7 and 2006/7

Overall, when major emergency large bowel resections for all diagnoses are considered, 30-day mortality has not appreciably lowered during the study years. Specifically, 30-day mortality within the first 5 study years (1996 to 2001) was 15.8% (7,273 of 45,941) compared with 15.3% (7,195 of 46,998) during the last 5 study years (2002 to 2007). Thirty-day mortality trends between 1996 and 2007 are illustrated in Figure 3 according to diagnostic

Table 3. Mortality Rates, Median Length of Stay, and 28 Day Readmission Rates after Large Bowel Emergency Colorectal Surgery, Including All Colonic and Rectal Procedures Listed in Table 1 between April 1996 And March 2007*

	Malignancy	Diverticular disease	Crohn disease	Ulcerative colitis	Obstruction and paralytic ileus	Vascular disorders of the intestine	Peritonitis
30-d mortality rates (number of deaths/total cases)	13.3 (5,292/39,824)	15.4 (3,066/19,874)	2.5 (127/5,152)	5.9 (124/2,097)	13.6 (1,119/8,274)	32.9 (1,138/3,464)	35.2 (651/1,852)
365-d mortality rates (number of deaths/total cases)	34.7 (6,086/17,537)	22.6 (2,042/9,040)	4.3 (102/2,376)	9.1 (85/937)	24.0 (902/3,765)	46.5 (760/1,633)	43.2 (378/875)
Median length of stay, d (interquartile range), n	17 (12−26), 39,824	16 (10−27), 19,874	14 (10−23), 5,152	23 (16−33), 2,097	15 (10−25), 8,274	15 (8−28), 3,464	14 (7−27), 1,852
Readmissions within 28 d of discharge, % (readmissions/total operative admissions)	7.6 (3,034/39,824)	8.1 (1,610/19,874)	12.7 (654/5,152)	14.1 (296/2,097)	9.5 (780/8,247)	10.3 (357/3,464)	6.4 (118/1,852)

*Except 365-d mortality rates, which were calculated between April 2000 and March 2005.

OPCS category. The chart illustrates the annual mortality rates when all major nonelective colorectal resections are considered.

Between the first and last study years, a 27.4% increase in the number of emergency right hemicolectomies performed for Crohn disease was observed (Pearson's $r = 0.755$, n = 3,962; p < 0.001). The annual number of emergency subtotal colectomy and ileostomy procedures (4-digit OPCS-4 subcodes H05.2 and H05.3) performed for UC decreased slightly during the study years (Pearson's $r = -474$, n = 1,309; p < 0.001). Specifically, 617 emergency subtotal colectomy procedures were carried out in the first 5 study years compared with 571 cases in the last 5 years. Emergency and elective right hemicolectomy and subtotal colectomy resection rates for Crohn disease and UC are illustrated in Figures 1 and 2, respectively.

The proportion of patients with a colorectal malignancy undergoing an emergency distal large bowel resection who underwent a Hartmann procedure increased from 0.37 in 1996/7 to 0.46 in 2006/7 (chi-square test, p < 0.001). The proportion of patients of distal bowel resection with a diagnosis of DD who underwent a Hartmann procedure was higher than that for cancer and increased from 0.65 to 0.70 throughout the study years (chi-square test, p = 0.002). Procedures that had been coded to sigmoid colectomy with an additional operative code used to denote a colostomy would not have been identified as Hartmann procedures from this analysis.

Between April 1996 and March 2006, 543(0.6%) of all emergency major colorectal procedures were carried out using a laparoscopic approach. The Y50.8 code includes laparoscopic conversions as well as those that were successfully completed using laparoscopy. Half of these procedures (270 of 543) were carried out in the last 3 years of the 10-year period examined. Of the total emergency laparoscopic colorectal procedures performed, 82 (15.1%), 75 (13.8%), and 165 (30.4%) were coded to diagnoses of IBD, DD, and colorectal malignancy, respectively. Nearly half (n = 257) of all emergency colorectal procedures that employed laparoscopy were right hemicolectomies, 96 (17.7%) were sigmoid colectomies and 84 (15.5%) were Hartmann procedures. In multivariate analyses, procedures that employed laparoscopic surgery failed to demonstrate either an independent reduction in-hospital stay (p = 0.102) or significant 30-day (p = 0.337) or 365-day (p = 0.508) mortality advantage. A nonsignificant trend toward higher 28-day readmission rates in patients who underwent a laparoscopically assisted procedure (10.3%; 53 of 543) was observed when compared with patients undergoing conventional surgery (8.6%; 7,886 of 92,127; chi-square test, p = 0.146).

Table 4. Logistic Regression Analysis for 30-d Mortality (between April 1, 1996, and March 31, 2006) and 365 Day Mortality (between April 1, 2000, and March 31, 2005)

	OR (95% CI of OR)				OR (95% CI of OR)			
	OR	Lower	Upper	p Value	OR	Lower	Upper	p Value
Male gender (compared with female gender)	1.00	0.96	1.04	0.882	1.00	0.95	1.04	0.882
Age, y				<0.001				<0.001
Younger than 55*	1.00				1.00			
55–69	2.97	2.71	3.25	<0.001	2.57	2.36	2.80	<0.001
70–79	6.25	5.73	6.82	<0.001	4.81	4.43	5.23	<0.001
Older than 80	12.31	11.27	13.45	<0.001	9.23	8.46	10.07	<0.001
Charlson comorbidity score				<0.001				<0.001
0*	1.0				1.00			
1	2.04	1.92	2.18	<0.001	1.96	1.82	2.13	<0.001
2	2.04	1.91	2.17	<0.001	2.63	2.44	2.85	<0.001
3	4.07	3.75	4.41	<0.001	4.40	3.97	4.87	<0.001
4	6.93	6.04	7.96	<0.001	6.96	5.78	8.38	<0.001
5	2.74	2.54	2.96	<0.001	7.61	6.95	8.33	<0.001
≥6	5.93	5.33	6.60	<0.001	10.13	8.85	11.60	<0.001
Carstairs deprivation index				<0.001				<0.001
1 Least deprived*	1.00				1.00			
2	1.08	1.01	1.16	0.019	1.11	1.03	1.20	0.004
3	1.16	1.09	1.24	<0.001	1.14	1.06	1.22	0.001
4	1.28	1.20	1.36	<0.001	1.26	1.17	1.36	<0.001
5 Most deprived	1.43	1.34	1.52	<0.001	1.39	1.29	1.50	<0.001
Unclassified	0.76	0.58	0.99	0.040	1.07	0.72	1.60	0.731
Diagnostic category				<0.001				<0.001
Malignant diagnosis*	1.00				1.00			
Other diagnosis	4.00	3.76	4.25	<0.001	3.09	2.87	3.34	<0.001
Ulcerative colitis	1.46	1.16	1.84	0.001	1.13	0.87	1.48	0.369
Diverticular disease	2.53	2.35	2.73	<0.001	1.89	1.73	2.07	<0.001
Crohn disease	1.38	1.13	1.68	0.002	0.80	0.64	0.99	0.042
Obstruction and paralytic ileus	2.52	2.31	2.76	<0.001	2.15	1.94	2.39	<0.001
Vascular disorder	7.30	6.62	8.06	<0.001	5.28	4.66	6.00	<0.001
Peritonitis	9.24	8.15	10.47	<0.001	5.41	4.59	6.38	<0.001
OPCS-4 code, emergency operation type				<0.001				<0.001
H07–right hemicolectomy*	1.00				1.00			
H08, H06, transverse and extended right hemicolectomy	1.33	1.24	1.43	<0.001	1.11	1.02	1.20	0.012
H09–left hemicolectomy	1.23	1.13	1.35	<0.001	0.90	0.81	1.00	0.051
H10–sigmoid colectomy	1.15	1.08	1.23	<0.001	0.86	0.79	0.92	<0.001
H05–total colectomy	2.18	1.97	2.41	<0.001	1.49	1.32	1.69	<0.001
H335–Hartmann procedure	1.58	1.50	1.67	<0.001	1.14	1.07	1.22	<0.001
H33.2, H33.3, H33.4, H33.6, H33.8, H33.9–rectal excision	0.92	0.83	1.02	0.102	0.78	0.70	0.87	<0.001
H04.1–panproctocolectomy and ileostomy	1.68	1.23	2.30	0.001	1.34	0.93	1.92	0.113
Laparoscopic approach (compared with open approach)	0.87	0.66	1.17	0.360	0.90	0.65	1.23	0.503

*Reference category.
OPCS-4, Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures, 4th revision; OR, odds ratio.

Table 5. Multiple Linear Regression of the Natural Logarithm of Length of Stay (and Back-Transformed) after Emergency Colorectal Surgery in English National Health Service Trusts between April 1, 1996 and March 31, 2006

	Exponential (β coefficient)	95% CI		
		Lower	Upper	p Value
Male gender (compared with female gender)	0.94	0.93	0.95	<0.001
Age, y				
Younger than 55	Reference			
55<69	1.19	1.17	1.21	<0.001
70<79	1.32	1.30	1.34	<0.001
Older than 80	1.32	1.30	1.34	<0.001
Carstairs deprivation index				
1 Least deprived	Reference			
2	1.03	1.02	1.05	<0.001
3	1.06	1.04	1.08	<0.001
4	1.08	1.07	1.10	<0.001
5 Most deprived	1.13	1.11	1.15	<0.001
Unclassified	1.00	0.94	1.05	0.892
Charlson comorbidity score				
0	Reference			
1	1.06	1.04	1.08	<0.001
2	0.95	0.93	0.96	<0.001
3	0.97	0.95	1.00	0.026
4	1.00	0.96	1.05	0.939
5	0.90	0.88	0.92	<0.001
≥6	0.93	0.90	0.96	<0.001
Emergency operation type				
H07—right hemicolectomy	Reference			
H08, H06—transverse and extended right hemicolectomy				
H09—left hemicolectomy	1.07	1.05	1.09	<0.001
H10—sigmoid colectomy	1.14	1.11	1.17	<0.001
H05—total colectomy	1.14	1.12	1.16	<0.001
H335—Hartmann procedure	1.25	1.22	1.29	<0.001
H33.2, H33.3, H33.4, H33.6, H33.8, H33.9—rectal excision	1.11	1.10	1.13	<0.001
H04.1—panproctocolectomy and ileostomy	1.24	1.21	1.27	<0.001
Diagnostic category				
Malignant diagnosis	Reference			
Other diagnosis	0.88	0.86	0.89	<0.001
Ulcerative colitis	1.22	1.16	1.27	<0.001
Diverticular disease	0.85	0.84	0.87	<0.001
Crohn disease	0.99	0.96	1.02	0.620
Obstruction	0.88	0.86	0.90	<0.001
Vascular disorder	0.78	0.76	0.81	<0.001
Peritonitis	0.70	0.67	0.73	<0.001
Laparoscopic approach (compared with the open approach)	0.92	0.87	0.98	<0.001

Figure 4 illustrates the absolute number of total colectomy resections carried out for patients assigned with a bacterial infection diagnosis during the 11-year period. Two diagnostic categories, ie, noninfective gastroenteritis and colitis (K52.9) and enterocolitis due to *Clostridium difficile* (A04.7) are included. Of 32 patients who underwent a total colectomy in the latter *C. difficile* enterocolitis (A04.7 ICD-10) category, 34.4% (11 of 32) died within 30 days of the procedure. Their median stay was 36.5 days (interquartile range 18.75 to 56 days; n = 32).

DISCUSSION

This is a large study of national nonelective colorectal practice during the last 11 years. Patients included in this study

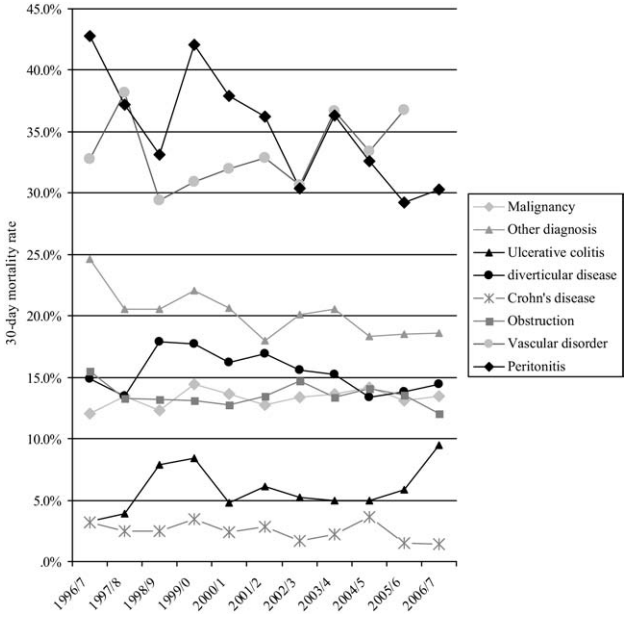

Figure 3. Thirty-day mortality trend for emergency major colorectal resection according to diagnostic category.

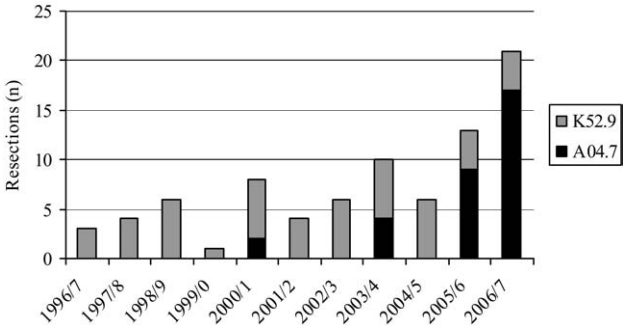

Figure 4. Absolute number of total colectomy resections carried out between April 1996 and March 2007 where a primary diagnosis of bacterial infection was coded. The two diagnostic codes included noninfective gastroenteritis and colitis (K52.9) and enterocolitis due to *Clostridium difficile* (A04.7).

represented those whose admission status was classified as nonelective. All patients underwent surgery during their urgent or emergency admission. As such, the definition of the urgency of the procedures themselves has been defined according to admission rather than procedure status. Definitive classification of the study procedures as emergency operations is, therefore, potentially inaccurate. However, the high-mortality outcomes observed within the study cohort clearly demonstrate that they represent a much higher-risk group than those categorized on the HES database as electives according to admission status. Specifically, 30-day mortality in patients admitted as electives and undergoing major colorectal resection approximates 3% to 4%, and mortality risk is approximately 4 times as great in the current study patient cohort.[8] The independent risks presented by advancing age, patient comorbidity, and social deprivation on mortality and duration of hospital stay are clearly demonstrated in this study. A possible temporal trend toward increased use of Hartmann procedures for distal large bowel emergencies was also observed. Evidence to support definitive reduction in perioperative mortality risk during recent years among patients undergoing nonelective large bowel surgery was not observed.

Important changes have occurred in the management of colorectal emergencies in recent years. Advances in intensive care medicine, a trend toward performing single-stage resections for large bowel emergencies (SCOTIA Study Group)[9-11] and improved medical treatments for IBD[12-14] have been implemented in routine clinical practice in many centers. In the United Kingdom, a government-funded body called the National Confidential Enquiry into Perioperative Deaths[15] was formed as a joint venture between anesthetic and surgical specialties in 1988. The remit of this organization is to improve standards of health care for the benefit of the public by reviewing patient care, undertaking research, and consequently publishing the results of these activities as well as making recommendations to hospital organizations (http://www.ncepod.org.uk/about.htm).

This study used the HES database to audit current national standards of emergency colorectal practice and evaluate changing trends in emergency colorectal workload. As stated here, our findings suggest that uptake of resections that maintain intestinal continuity is low in the United Kingdom. Theoretically, centralization of colorectal expertise[16] and use of colorectal stents as a "bridge to semi-elective surgery"[17] should have facilitated some reduction in stoma formation. It is, however, also possible that delayed dissipation of best practice to the clinical frontline, predominance of noncolorectal specialized or junior personnel on the on-call rota, or a genuine reluctance for emergency surgeons to change practice account for this finding. In addition, consultant expansion, rapid access for suspected cancer cases, as well as multidisciplinary team decision-making might have diminished the number of advanced cancer cases presenting as emergencies. Similarly, a more conservative trend in DD might subselect the more advanced cases for operations, thus accounting for the apparent increase in stoma formation rates noted within this group. The H09.5, H10.5, and H33.6 subcodes within the respective H09−excision of left hemicolon, H10−excision of sigmoid colon, and H33−anterior resection procedure categories represent those where colectomy and exteriorization of bowel were performed. In our analyses, these subcodes were not removed because they represented small, and less frequently used, subcode categories. Importantly, repeat analysis with the addition of the procedures

assigned to H09.5, H10.5, and H33.6 subcodes to the H33.5 Hartmann procedure category did not alter time-trend results findings. The finding that national intestinal continuity rates are not increasing requires caution, as Hartmann rates might be underestimated in this study. We used the H33.5 code to denote a definite Hartmann procedure. Some Hartmann procedures might have been coded to the H10 sigmoid colectomy code with another separate secondary operative code assigned to denote formation of a colostomy. The latter cases would have been identified only as sigmoid colectomies within our data because of the method by which the principal operative code was used to define the operative intervention. Recent findings by Jeyarajah and colleagues (personal communication, June 2009) suggest that, at least for DD, a high proportion of Hartmann procedures might be coded to a formation of colostomy code rather than the H33.5 code. Therefore, it must be acknowledged that our findings possibly underestimate nonrestorative procedure rates. In our analysis, we found that the trend toward nonrestorative resections is increasing. Although we acknowledged that a definitive estimate of this trend is not measurable in the current analysis, it is unlikely that the trend is grossly inaccurate and masks actual increases in restoration of intestinal continuity rates. Overall, it would appear that the rate of nonrestorative resectional surgery is not decreasing in England.

In spite of advances in medical management, a dramatic decrease in emergency colorectal surgery for IBD has not been observed in recent years. A decrease in the subtotal colectomy rate for UC observed in the last 2 study years in Figure 2, brought about largely through a decrease in procedures coded as electives, can represent recent improvements in medical management. Further examination of this trend is required to determine whether it is continuing. One potential inaccuracy about IBD trends observed in this study is that we looked solely at colonic and rectal excision codes. Importantly, OPCS-4 coding states clearly that ileocecal resection should be assigned to the right hemicolectomy code. Despite this, some terminal ileal resections for Crohn disease, coded to small bowel resection OPCS-4 codes, might not have been incorporated. Future studies will need to identify the changing trends in total Crohn operative caseload in the context of potential changes in disease prevalence along with comprehensive incorporation of additional excision of ileum operative codes.

Age and comorbidity were identified as strong independent predictors of death after emergency colorectal surgery in this study. Our findings are largely consistent with those of other investigators.[18-21] We also observed an excess of deaths occurring beyond the perioperative period, but within 1 year of surgery. Lacking cause of death information, unfortunately, limits any conclusions that might be extrapolated from this finding. Future studies will need to determine whether this finding is consistent when evaluated on other large datasets and also seek to identify the cause for medium-term mortality in patients that have undergone major nonelective bowel surgery. In addition, social deprivation was identified as another independent predictor of mortality. Other researchers have suggested that social deprivation can be used as a surrogate marker for poorly controlled comorbidities in this context.[22] In addition to the risk factors mentioned here, emergency surgery for DD was associated with more than double the independent mortality risk compared with malignant disease in this study. This might be a reflection of the presentation of the disease, with DD more likely to present with peritonitis and malignancy with large bowel obstruction. Unfortunately, this distinction cannot be made definitively because of the coding shortcomings described here. Procedures coded to peritonitis and vascular disorders of the intestine were associated with very high mortality. Accurate analysis of outcomes trends according to diagnostic category is hazardous, as patients with feculent peritonitis because of DD might have been coded within either the peritonitis or DD category. Unless coding habits were homogeneous throughout the study years, changing case-mix can underlie some of the mortality trend changes observed in Figure 3.

Coding accuracy is fundamental to interpretation of investigations that employ HES data. Despite the acknowledged potential shortcomings of administrative data, such as HES, its accuracy has been validated against a well-recognized national clinical colorectal dataset.[4,5] In addition, Campbell and colleagues[23] investigated the accuracy of hospital statistics data in the United Kingdom through systematic review of studies comparing routinely collected data with case note review. They determined that median coding accuracy rates were 91% for diagnostic codes and 69.5% for operation or procedure codes in studies in England or Wales; 82% for diagnostic codes and 98% for operation or procedure codes in Scottish studies.

Total colectomy in patients assigned a primary diagnostic code of *C. difficile* enterocolitis was associated with 30-day mortality in approximately one-third of patients. Recent increases in resections performed for the latter diagnostic group, as evidenced by Figure 4, might represent evolution of a genuinely more aggressive disease process in recent years or improved coding accuracy. *C. difficile* associated colitis appears to be increasing in the Western world.[24-26] This is also associated with an increase in the rate of surgery for this condition, which is associated with a high mortality. This trend is reflected in our analysis. The

high mortality rate associated with surgery is reflective of other units around the world.[27,28]

Emergency admissions account for approximately one-third of total inpatient caseload in both NHS and North American general surgical units.[29,30] As such, the duration of stay of patients undergoing emergency colorectal surgery represents a substantial marker of hospital resource burden. Our findings determined that the median hospital stay for patients admitted as emergencies varied from 17 to 23 days, depending on the diagnosis. UC was associated with the longest hospital stay and Crohn disease with the highest readmission rate, at 28 days. This is consistent with the chronic nature of both diseases, and might be a reflection of the need for concomitant prolonged medical management. Importantly, the duration of stay in this study represents the total length of the index admission, thereby including preoperative stay. In the context of emergency surgery, diagnostic delays and preoperative medical treatment can contribute to prolonged total admission. In this study, advanced age and social deprivation were independently associated with lengthier stay. This highlights the important supportive function that elderly care medicine and social services can offer to facilitate patient rehabilitation and discharge from acute surgical units back to the community.

This study defines current outcomes after everyday emergency surgical practice in NHS hospitals. In addition, it highlights important predictors of adverse outcomes after acute surgical care. Additional investigation is required to identify the reliability and potential future use of HES data for monitoring clinical outcomes in this context. In particular, the construction of validated indicators of quality can facilitate future performance comparison between providers of emergency colorectal surgical care.

Author Contributions

Study conception and design: Faiz, Bottle, Aylin
Acquisition of data: Bottle, Aylin
Analysis and interpretation of data: Faiz, Warusavitarne, Bottle, Clark, Darzi, Aylin
Drafting of manuscript: Faiz, Warusavitarne, Bottle, Aylin
Critical revision: Tekkis, Clark, Darzi, Aylin

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