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Original Research

Evaluating the effects of surgical subspecialisation on patient outcomes following emergency laparotomy: A retrospective cohort study

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A R T I C L E I N F O

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A B S T R A C T

Background: General surgeons have become increasingly subspecialised in their elective practice. Emergency laparotomies, however, are performed by a range of subspecialists who may or may not have an interest in the affected area of gastrointestinal tract. This retrospective cohort study evaluates the impact of surgical subspecialisation on patient outcomes following emergency laparotomy.

Methods: Data was collected for patients who underwent an emergency abdominal procedure on the gastrointestinal tract in the North of England from 2001 to 2016. This included demographics, co-morbidities, diagnoses and procedures undertaken. Patients were grouped according to consultants' subspecialist interest. The primary outcome of interest was 30-day postoperative mortality.

Results: 24,291 emergency laparotomies were performed with an associated 30-day postoperative mortality of 11.7%. Laparotomies undertaken by upper gastrointestinal (UGI) or colorectal surgeons have significantly lower mortality (10.1%) when compared with other subspecialities (13.5%). More specifically, mortality was decreased for UGI (7.9% vs. 12.9%) and colorectal procedures (10.9% vs. 14.2%) when performed by surgeons with a specialist interest in the relevant area of the gastrointestinal tract (both $p < 0.001$). The utilisation of laparoscopic surgery is higher, in both UGI (21.8% vs. 9.0%) and colorectal procedures (7.2% vs. 3.5%), when the causative pathology is relevant to the surgeon's subspeciality (both $p < 0.001$).

Conclusion: Mortality following emergency laparotomy is improved when performed under the care of gastrointestinal surgeons. Both UGI and colorectal emergency procedures have improved outcomes, with lower mortality and higher rates of laparoscopy, when under the care of a surgeon with a subspecialist interest in the affected area of the gastrointestinal tract.

1. Introduction

Emergency laparotomy is a surgical procedure performed for patients with often life-threatening pathology affecting the gastrointestinal tract. Approximately 30 000 emergency laparotomies are performed across England and Wales every year, with recent data showing an associated 30-day postoperative mortality of 9.5% [range 0–19.6%] [1]. While outcomes have improved over time, these procedures are still associated with high morbidity and mortality [2–4].

A number of contributing factors have been considered to identify to what extent this excess mortality is avoidable. These have ranged from the ‘weekend effect’ [5–7] to consultant involvement in theatre [8] and 24 h access to essential radiology services [9]. An area that is comparatively neglected within the existing literature is the impact of subspecialisation within surgical practice. In the UK, while all ‘general surgeons’ are trained in emergency gastrointestinal surgery, most have a subspeciality, such as colorectal, upper gastrointestinal (UGI) or breast, that makes up the majority of their elective practice [10]. The most recent NELA report suggested that those with regular gastrointestinal elective surgical practice may be best placed to perform emergency laparotomy but contained no analysis of how subspeciality influenced patient outcomes [1]. The impact of subspecialisation on emergency laparotomy remains poorly understood.

A number of smaller studies have suggested improved outcomes in particular types of emergency surgery when performed by appropriate subspecialists. Robson et al. demonstrated a near 50% decreased mortality in patients who underwent surgery for perforated and bleeding peptic ulcers when performed by an UGI surgeon [11]. Similarly favourable clinical outcomes have been described following major gastric procedures [12] and urgent cholecystectomy [13]. Colorectal

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subspecialist elective operating has been linked to favourable outcomes for colorectal cancer resections [14], particularly rectal cancer [15,16], with high volume of relevant practice considered key to achieving good outcomes. In the emergency setting, colorectal surgeons have similarly been shown to have lower mortality and stoma formation rates in patients with diverticulitis [17].

The aim of this study is to further examine the effects of consultant subspecialisation on patient outcomes following emergency laparotomy across National Health Service (NHS) hospitals in the North of England over a 15-year period.

2. Methods

Data containing details of all admissions is routinely collected by submission to the Health and Social Care Information Centre to provide Hospital Episode Statistics (HES) [18]. Following Caldicott approval, these anonymised data were sought from all acute NHS Foundation Trusts in the North of England. Data were requested for all emergency admissions under a general surgeon between 1 December 2001 and 30 November 2016. These dates were chosen to cover a complete 15-year period ending alongside the recent NELA Audit Year 3 (01/12/2015-30/11/2016). Data fields that were requested are listed in Appendix 1. Patient data was anonymised irreversibly prior to being provided to the authors.

2.1. Data definitions and management

The cohort comprised of all patients aged 18 years or more who were admitted under a general surgeon as an emergency and underwent an expedited, urgent or emergency (by National Confidential Enquiry into Patient Outcome and Death (NCEPOD) definitions) abdominal procedure on the gastrointestinal tract [19]. This included open, laparoscopic, and laparoscopic assisted procedures as detailed in Appendix 2. Postal codes were converted to Index of Multiple Deprivation (IMD) scores using the online postcode conversion tool [20] and then converted to deprivation quintiles [21]. Weekends were defined as Saturday and Sunday, including bank holidays, with weekdays Monday to Friday. Co-morbidity data were generated by mapping secondary ICD-10 diagnostic codes to co-morbidities. These were then converted to Charlson scores [21,22] using weightings employed by the hospital standardised mortality ratio [23,24]. To account partially for the severity of patients' illnesses, a clinical risk grouping was generated by assigning patients to 1 of 259 diagnostic groups. This was derived from, the primary ICD-10 diagnosis field using the Clinical Classification Software (CCS) [25]. Patients were ranked into five equally sized groups to create a five-tier clinical risk variable based on the 30-day crude in-hospital mortality rate for the primary diagnoses. Primary procedure data were also utilised to account for any further differences in case mix by additionally adjusting for quartile of risk of procedure (derived by ranking procedures into four equal sized groups based on procedure specific 30-day in-patient mortality rates). Operation codes eligible for this study were derived from NELA guidance to maintain a comparable study population (Appendix 2 [26]). Operations were divided into groups according to intervention type: operations on the UGI tract, small bowel, lower GI tract, or other. Subspecialist procedures to assess practice within each primary subspeciality were derived from: UGI operation with or without small bowel procedure, or colorectal operation with or without small bowel procedure.

The data provided enabled calculation of age at admission, day of admission, season of admission, duration of hospital stay, time to procedure from admission, day of procedure, and day of in-hospital death. The mortality outcome of interest was in-hospital death within 30 days of procedure. Admissions with missing patient characteristics or 30-day in-hospital mortality (0.54 per cent of 490,380 cases) were excluded from the analysis.

The named responsible consultant for the relevant hospital spell was provided in the dataset. Using information from NHS search and other subspecialist society websites [27–29], names were mapped to a subspeciality in which the consultant predominantly practiced during the year group of the study. Subspecialties were categorised as colorectal, upper GI or other 'general' surgeons. The last group included breast, vascular and other non-gastrointestinal subspeciality 'general' surgeons who contributed towards emergency on-call rotas during the study period. During the 15 years studied, no admitting hospitals within the region utilised separate subspecialties of on-call consultant (e.g. upper and lower GI split) for emergency admissions.

This work has been reported in line with the STROCSS criteria [30] and registered in a publically accessible database (UIN: researchregistry4521).

2.2. Statistical analysis

These retrospective observational data were analysed with consideration of the subspeciality of the responsible consultant and the affected area of the gastrointestinal tract. Categorical data were summarized using frequencies and percentages, and continuous data using the mean and 95 per cent confidence interval. Differences in case mixes between these groups were investigated using Pearson's χ^2 test for trend for categorical variables, and differences between continuous variables were analysed using ANOVA with *post hoc* testing.

The factors associated with 30-day in-hospital death following the surgical procedure were determined using a Cox regression model with a time-dependent co-variable to describe the hazards associated with emergency laparotomy. Factors with $P < 0.200$ in the univariable models were entered into multivariable models. The multivariable models were built by inclusion of variables that achieved $P < 0.050$ and significant improvement of model fit (reduction in Akaike's Information Criterion of at least 4) [31,32]. Data were stored and processed in Excel® 2010 and R Open (Microsoft, Redmond, Washington, USA) and analyses were undertaken using Stata® 13.1 software (StataCorp, College Station, Texas, USA). Statistical significance was defined in all cases as $P < 0.050$.

3. Results

3.1. Patient characteristics by surgeon subspeciality

Over 15 years, there were 490 380 emergency general surgical admissions to NHS hospitals within the North of England. Of these, 24,291 patients (5%) underwent a NELA emergency gastrointestinal procedure. There were 2828 in-hospital deaths within 30 days of procedure (11.7%).

Over the study period, the distribution of case numbers between subspecialties changed markedly (Table 1). The proportion of laparotomies undertaken by other general subspecialties (e.g. breast, hepatopancreatobiliary, or vascular surgeons) has more than halved between 2001-2004 and 2013–2016 (60.3% vs. 24.0%). Colorectal (27.4% vs. 46.2%) and UGI (12.3% vs. 29.8%) specialists have consequently increased their numbers of emergency laparotomies performed. The mean age, sex distribution and deprivation scores were comparable between groups. There was, however, significant differences seen in Charlson scores, as a measure of existing co-morbidities. Those operated on under colorectal and UGI surgeons more commonly had scores of 0 or 1–4, while a greater proportion of higher risk patients with a score ≥5 ($p < 0.001$) were operated on under other general surgeons. Similarly, clinical and operative risk groups revealed more high-risk cases were undertaken by other general subspecialties than by colorectal or UGI surgeons.

3.2. Effect of surgeon subspecialisation on patient outcomes

Emergency laparotomy was associated with an overall 30-day

Table 1
Baseline characteristics of patients who underwent an emergency laparotomy, by consultant subspeciality.

	Consultant Subspeciality				p-value
	Colorectal (n = 8236)	UGI (n = 5021)	Other (n = 11034)	Overall (n = 24291)	
Age *‡	59.7 (59.3, 60.1)	59.2 (58.7, 59.7)	61.1 (60.7, 61.4)	60.2 (60.0, 60.5)	< 0.001
Sex					0.581
Male	3813 (46.3)	2299 (45.8)	5149 (46.7)	11 261 (46.4)	
Female	4422 (53.7)	2722 (54.2)	5885 (53.3)	13 029 (53.6)	
Year Group					< 0.001
2001–2004	1351 (27.4)	609 (12.3)	2973 (60.3)	4933	
2004–2007	1546 (30.6)	914 (18.1)	2590 (51.3)	5050	
2007–2010	1570 (31.5)	1071 (21.5)	2341 (47.0)	4982	
2010–2013	1723 (35.2)	1105 (22.6)	2069 (42.3)	2897	
2013–2016	2046 (46.2)	1322 (29.8)	1061 (24.0)	4429	
Charlson Score					< 0.001
0–1	3049 (37.0)	1761 (35.1)	3040 (27.6)	7850 (32.3)	
2–4	3097 (37.6)	1841 (36.7)	3692 (33.5)	8630 (35.5)	
≥5	2090 (25.4)	1419 (28.3)	4302 (39.0)	7811 (32.2)	
Deprivation Score					< 0.001
1 (most)	1912 (23.7)	1233 (25.7)	2075 (26.7)	5220 (25.3)	
2	1766 (21.9)	1019 (21.2)	1922 (24.7)	4707 (22.8)	
3	1552 (19.3)	812 (16.9)	1448 (18.6)	3812 (18.5)	
4	1111 (13.8)	678 (14.1)	992 (12.8)	2781 (13.5)	
5 (least)	1721 (21.3)	1064 (22.1)	1331 (17.1)	4116 (19.9)	
Clinical Risk Group					< 0.001
1 (lowest)	1235 (15.0)	434 (8.6)	1145 (10.4)	2814 (11.6)	
2	1264 (15.3)	971 (19.3)	629 (5.7)	2864 (11.8)	
3	1168 (14.2)	697 (13.9)	2070 (18.8)	3935 (16.2)	
4	1427 (17.3)	931 (18.5)	2653 (24.0)	5011 (20.6)	
5 (highest)	3142 (38.1)	1988 (39.6)	4537 (41.1)	9667 (39.8)	
Admission Method					< 0.001
A&E	4193 (50.9)	2738 (54.5)	5383 (48.8)	12 314 (50.7)	
GP	2567 (31.2)	1212 (24.1)	3383 (30.7)	7162 (29.5)	
Consultant Clinic	488 (5.9)	263 (5.2)	364 (3.3)	1115 (4.6)	
Other	988 (12.0)	808 (16.1)	1904 (17.3)	3700 (15.2)	
Trust Size					< 0.001
Small/Medium	4432 (53.8)	2409 (48.0)	4295 (38.9)	11 136 (45.8)	
Large/Very Large	3804 (46.2)	2612 (52.0)	6739 (61.1)	13 155 (54.2)	
Season					0.242
Spring	2050 (24.9)	1316 (26.2)	2864 (26.0)	6230 (25.6)	
Summer	2137 (25.9)	1310 (26.1)	2846 (25.8)	6293 (25.9)	
Autumn	2030 (24.7)	1220 (24.3)	2600 (23.6)	5852 (24.1)	
Winter	2017 (24.5)	1175 (23.4)	2724 (24.7)	5916 (24.4)	
Day of Week of Admission					0.069
Weekday	6221 (75.5)	3817 (76.0)	8218 (74.5)	18 256 (75.2)	
Weekend/Bank Holiday	2015 (24.5)	1204 (24.0)	2816 (25.5)	6035 (24.8)	
Day of Week of Operation					< 0.001
Weekday	6322 (77.6)	3797 (78.2)	6971 (75.4)	17 090 (76.8)	
Weekend/Bank Holiday	1830 (22.4)	1060 (21.8)	2276 (24.6)	5166 (23.2)	
Operative Risk Group					< 0.001
1 (lowest)	1423 (17.3)	527 (10.5)	1333 (12.1)	3283 (13.5)	
2	1373 (16.7)	951 (18.9)	2002 (18.1)	4326 (17.8)	
3	1920 (23.3)	1315 (26.2)	2249 (20.4)	5484 (22.6)	
4 (highest)	3520 (42.7)	2228 (44.4)	5450 (49.4)	11,198 (46.1)	
Operative Approach					< 0.001
Laparotomy	7105 (86.9)	4020 (81.0)	10 018 (91.3)	21 143 (87.7)	
Laparoscopic	887 (10.9)	805 (16.2)	724 (6.6)	2416 (10.0)	
Laparoscopic converted to open	182 (2.2)	140 (2.8)	233 (2.1)	555 (2.3)	

Values in parenthesis are percentages unless indicated otherwise. *values displayed are mean (95% c.i.). Percentages and proportions were derived by excluding missing data from the variable. χ^2 test for difference, except ‡ANOVA. UGI, upper-gastrointestinal surgeon; A&E, accident and emergency department; GP, general practitioner.

postoperative mortality of 11.7% (95% CI: 11.0%–12.4%). Over time, this figure has fallen consistently amongst all subspecialties (Table 2). Both 30- and 90-day postoperative mortality were however, significantly lower for colorectal and UGI surgeons when compared with other general subspecialties (all $p < 0.001$). Sub-analysis of 30-day postoperative mortality within each 3-year period showed consistently improved outcomes for colorectal and UGI surgeons. Total length of inpatient stay was shortest amongst those operated on by UGI subspecialists. While little variability was seen in time to procedure between the groups, postoperative length of stay was decreased in both the UGI and colorectal groups ($p < 0.001$) when compared with other subspecialties.

Overall, laparotomies undertaken under the care of UGI and colorectal surgeons had a significantly lower mortality ($p < 0.001$) compared with other subspecialties (10.1 vs. 13.5% respectively, Table 3). No significant difference was identified between UGI (10.0%) and colorectal (10.2%) surgeons overall.

Laparotomies performed on patients with UGI pathology that were undertaken by UGI surgeons had a significantly lower mortality rate compared with other subspecialties ($p < 0.017$, Table 3). On direct

Table 2
– Outcomes for patients undergoing emergency laparotomy, by consultant subspeciality.

	Consultant Subspeciality				p-value
	Colorectal (n = 8236)	Upper Gastrointestinal (n = 5021)	Other (n = 11034)	Overall (n = 24291)	
Overall 30-Day Mortality	10.2 (839)	10.0 (500)	13.5 (1489)	11.7 (2828)	< 0.001
2001–2004	13.9 (188)	15.6 (95)	17.5 (17.5)	16.3 (802)	0.012
2004–2007	12.0 (185)	14.7 (134)	15.3 (395)	14.2 (714)	0.011
2007–2010	10.6 (167)	9.5 (102)	12.5 (291)	11.3 (560)	0.026
2010–2013	8.2 (141)	6.7 (74)	8.7 (180)	8.1 (395)	0.139
2013–2016	7.7 (158)	7.2 (95)	9.8 (104)	8.1 (357)	0.049
90-Day Mortality	11.1 (914)	11.1 (556)	14.8 (1636)	12.8 (3106)	< 0.001
Total Length of Stay (Days)* ‡	16.7 (16.2, 17.1)	16.0 (15.4, 16.6)	17.5 (17.2, 17.9)	16.9 (16.7, 17.2)	< 0.001
Time to Procedure (Days)* ‡	3.5 (3.3, 3.7)	3.6 (3.3, 3.8)	3.6 (3.4, 3.7)	3.5 (3.4, 3.6)	0.690
Post-operative Length of Stay (Days)* ‡	13.3 (12.9, 13.7)	12.6 (12.1, 13.0)	13.9 (13.6, 14.3)	13.4 (13.2, 13.6)	< 0.001

Values in parenthesis are percentages unless indicated otherwise. *values displayed are mean (95% c.i.). Percentages and proportions were derived by excluding missing data from the variable. χ^2 test for difference, except ‡ANOVA.

comparison with the outcomes of colorectal surgeons, there remained a significantly reduced mortality for UGI laparotomies (7.9% vs. 12.5%, $p < 0.012$). Multivariate cox regression revealed an upper GI subspecialist to be an independent positive predictor of survival following laparotomy for UGI pathology (HR 0.84, CI 0.71–0.95, p = 0.011, Appendix 3).

A significantly lower mortality was seen in colorectal procedures when performed by a colorectal specialist compared to other specialists ($p < 0.001$, Table 3). The difference between colorectal and UGI was not statistically significant for these procedures (p = 0.129). Analysis by multivariate regression suggested surgery being performed by a colorectal subspecialist was independently associated with lower 30-day mortality (HR 0.83, CI 0.73–0.96, p = 0.016, Appendix 4).

3.3. Subspeciality utilisation of laparoscopic surgery

Emergency laparotomy is a procedure that is most commonly performed as open surgery. The proportion of procedures performed laparoscopically has however, increased significantly ($p < 0.001$) over the 15-years studied. In 2001–2004, 1.4% of cases were performed laparoscopically compared with 20.1% over 2013–2016. A further 4.3% being laparoscopic converted to open.

The use of laparoscopy, for patients with UGI pathology, was shown to be significantly higher ($p < 0.001$) amongst UGI specialists who were over twice as likely to undertake procedures laparoscopically than other subspecialists (Table 4a). These procedures were found to be associated with a considerably lower mortality (3.8% vs. 13.4%) when compared with open procedures. While lower mortality rates were seen for open UGI procedures when performed by an UGI specialist when compared with other subspecialties (11.3% vs. 14.2%) this was not found to be statistically significant (p = 0.092). There was also no significant difference in mortality for UGI procedures performed laparoscopically (p = 0.830) or converted to open (p = 0.765).

The utilisation of laparoscopic surgery for patients with colorectal pathology has remained higher amongst colorectal specialists than other subspecialists consistently over time ($p < 0.001$, Table 4b). Procedures performed laparoscopically are associated with lower mortality (4.5% vs. 14.2%) when compared with open procedures ($p < 0.001$). Lower GI procedures performed by colorectal surgeons have significantly lower mortality rates ($p < 0.001$) when performed open (12.2% vs. 15.6%), but no difference was seen with other operative approaches.

4. Discussion

This study has identified interesting trends in emergency laparotomy outcomes from the North of England. Most notably, 30-day postoperative mortality has more than halved, over the last 15 years, from 16.3% to 8.1%. This improving trend is similar to that already described in the literature [2,3,33]. We found recent mortality rates to be slightly lower than those described in the latest NELA's report [1]. The slight difference observed between NELA's figures and our own are likely representative of the incomplete case ascertainment in the NELA audit. Their fourth report quotes a case ascertainment rate of 83%, with

Table 3
– Effect of consultant subspeciality and laparotomy indication on 30-day mortality.

		Laparotomy Type						
		UGI	UGI ± SB	LGI	LGI ± SB	Non-UGI/LGI	SB only	Overall
UGI vs. Colorectal	UGI Surgeon	48 (7.9)	66 (9.6)	106 (12.8)	128 (13.5)	231 (8.5)	75 (11.1)	500 (10.0)
	Colorectal Surgeon	58 (12.5)	63 (13.0)	257 (10.9)	313 (11.5)	348 (9.0)	115 (10.0)	839 (10.2)
	p-value	0.012	0.072	0.129	0.114	0.543	0.456	0.672
UGI vs. other subspecialties	UGI Surgeon	48 (7.9)	66 (9.6)	106 (12.8)	128 (13.5)	231 (8.5)	75 (11.1)	500 (10.0)
	Other subspecialties	187 (12.9)	207 (13.2)	659 (12.9)	787 (13.5)	1040 (11.3)	294 (11.0)	2328 (12.1)
	p-value	< 0.001	0.017	0.986	0.992	< 0.001	0.968	< 0.001
Colorectal vs. other subspecialties	Colorectal Surgeon	598 (12.5)	63 (13.0)	257 (10.9)	313 (11.5)	348 (9.0)	115 (10.0)	839 (10.2)
	Other subspecialties	177 (11.1)	210 (11.9)	508 (14.2)	602 (14.7)	923 (11.5)	254 (11.6)	1989 (12.4)
	p-value	0.393	0.511	< 0.001	< 0.001	< 0.001	0.157	< 0.001
UGI & Colorectal vs. other subspecialties	UGI & Colorectal Surgeons	106 (9.9)	129 (11.0)	363 (11.4)	441 (12.0)	579 (8.8)	190 (10.4)	1339 (10.1)
	Other subspecialties	129 (13.0)	144 (13.3)	402 (14.6)	474 (15.1)	692 (13.1)	179 (11.8)	1489 (13.5)
	p-value	0.023	0.098	< 0.001	< 0.001	< 0.001	0.187	< 0.001

Values in parenthesis are percentages. Percentages and proportions were derived by excluding missing data from the variable. χ^2 test for difference. UGI, upper gastrointestinal; SB, small bowel; LGI, lower gastrointestinal.

Table 4a
Differences in operative approach and 30-day mortality for upper gastrointestinal (with or without small bowel) procedures over time, comparing different subspecialists.

	Study Period					Overall	p-value	30-day mortality
	2001-2004	2004–2007	2007–2010	2010–2013	2013–2016			
Open (Laparotomy)	601 (96.3)	516 (91.8)	340 (80.4)	259 (75.5)	212 (69.7)	1928 (85.5)	< 0.001	258 (13.4)
UGI Surgeon	117 (91.4)	119 (82.6)	103 (70.5)	99 (76.2)	85 (62.5)	523 (76.5)		59 (11.3)
Other Subspecialties	484 (97.6)	397 (95.0)	237 (85.6)	160 (75.1)	127 (75.6)	1405 (89.4)		199 (14.2)
Laparoscopic	23 (3.7)	39 (6.9)	70 (16.5)	77 (22.4)	81 (26.6)	290 (12.9)	< 0.001	11 (3.8)
UGI Surgeon	11 (8.6)	22 (15.3)	39 (26.7)	29 (22.3)	48 (35.3)	149 (21.8)		6 (4.0)
Other Subspecialties	12 (2.4)	17 (4.1)	31 (11.2)	48 (22.5)	33 (19.6)	141 (9.0)		5 (3.5)
Laparoscopic Converted to Open	0 (0)	7 (1.2)	13 (3.1)	7 (2.0)	11 (3.6)	38 (1.7)	0.910	4 (10.5)
UGI Surgeon	0 (0)	3 (2.1)	4 (2.7)	2 (1.5)	3 (2.2)	12 (1.8)		1 (8.3)
Other Subspecialties	0 (0)	4 (1.0)	9 (3.2)	5 (2.3)	8 (4.8)	26 (1.6)		3 (11.5)

Values in parenthesis are percentages unless indicated otherwise. *values displayed are mean (95% c.i.). Percentages and proportions were derived by excluding missing data from the variable. χ^2 test for difference, except ‡ANOVA. UGI, upper gastrointestinal surgeon.

this being calculated by comparison against HES data, such as that used in this study [1]. Over the 15 years considered, countless advances will have been seen within emergency, intensive care and radiology services. These will have undoubtedly contributed to this improved survival alongside improvements in emergency general surgical care. This study focussed on the potential association with the trend of subspecialisation within general surgery.

The most recent National Emergency Laparotomy Audit (NELA) report suggests that 'general' or 'emergency general' surgeons performed only 19% of emergency laparotomies. While colorectal (54%) and UGI (18%) specialists perform the majority, many other subspecialists who do not electively perform gastrointestinal surgery still contribute towards emergency on-call rotas [4]. In our study, upper gastrointestinal and colorectal subspecialists performed an increasing proportion of emergency laparotomies over the time period. The percentage of laparotomies performed by other general surgery subspecialists is less than half that of 15 years ago. NELA have identified similar trends throughout the country in their last three annual reports and, in particular, highlighted a 50% reduction in vascular surgeons participating in general surgery on-call rotas [2–4]. It is not known whether this change has consciously been made with consideration of potentially improved patient outcomes.

Our results showed that colorectal and UGI surgeons have significantly better outcomes than other subspecialties, with lower 30- and 90-day postoperative mortality and decreased length of inpatient stay. This association can be seen consistently over time alongside the overall trend of improving postoperative mortality. Furthermore, when procedures related to the area of the gastrointestinal tract relevant to their elective subspeciality are performed under their care, their emergency mortality is lower still. This remained true after multivariate adjustment, which looked at this alongside other potentially contributing covariates. Patient populations did vary between those operated on by gastrointestinal specialists and other general surgeons. Significantly younger and less comorbid patients were seen in the UGI and colorectal cohorts and this is likely representative of favourable patient selection by these subspecialists. Outcomes remained better however, for gastrointestinal subspecialists, following multivariate adjustment for the improved case-mix. Increasing utilisation of laparoscopic surgery was seen amongst subspecialists performing laparotomies relevant to their elective specialty. Mortality figures were similar however, for all general surgeons across these minimally invasive procedures, most likely reflecting appropriate case selection of patients.

While previous work has highlighted the benefits of subspecialisation in both UGI [11,12] and colorectal [14–17,34] surgery, no studies have yet more broadly considered emergency laparotomy. Within the literature, smaller patient cohorts are studied from datasets that often preceded many of the interventions and recommendations, such as the NCEPOD guidance, that has driven improvement in this area. There is, as such, a clear paucity of contemporary research considering the impact of subspecialisation outcomes following emergency laparotomy, with this paper being the first to consider this.

Hospital Episode Statistics (HES) data utilises clinical coding, the accuracy of which often relies upon good documentation from medical staff and can be limited by statistical classification of clinical terminology. There is no reason to think, however, that any systematic bias exists within coding data over time. The size of the dataset makes any potential individual errors unlikely to bias the final results. Systematic review into the accuracy of such datasets has reassuringly show vast

Table 4b
Differences in operative approach and 30-day mortality for colorectal (with or without small bowel) procedures over time, comparing different subspecialists.

	Study Period					Overall	p-value	30-day mortality
	2001-2004	2004–2007	2007–2010	2010–2013	2013–2016			
Open (Laparotomy)	1554 (99.2)	1595 (98.9)	1255 (92.8)	1018 (85.8)	839 (79.5)	6261 (92.4)	< 0.001	891 (14.2)
Colorectal Surgeon	488 (98.2)	601 (98.8)	504 (93.2)	428 (85.6)	442 (78.6)	2463 (91.0)		300 (12.2)
Other Subspecialties	1066 (99.7)	994 (98.9)	751 (92.5)	590 (85.9)	397 (80.4)	3798 (93.4)		591 (15.6)
Laparoscopic	12 (0.8)	10 (0.6)	58 (4.3)	109 (9.2)	148 (14.0)	337 (5.0)	< 0.001	15 (4.5)
Colorectal Surgeon	9 (1.8)	5 (0.8)	29 (5.4)	56 (11.2)	95 (16.9)	194 (7.2)		10 (5.2)
Other Subspecialties	3 (0.3)	5 (0.5)	29 (3.6)	53 (7.7)	53 (10.7)	143 (3.5)		5 (3.5)
Laparoscopic Converted to Open	0 (0)	8 (0.5)	40 (3.0)	60 (5.1)	69 (6.5)	177 (2.6)	0.313	8 (4.5)
Colorectal Surgeon	0 (0)	2 (0.3)	8 (1.5)	16 (3.2)	25 (4.4)	51 (1.9)		3 (5.9)
Other Subspecialties	0 (0)	6 (0.6)	32 (3.9)	44 (6.4)	44 (8.9)	126 (3.1)		5 (4.0)

Values in parenthesis are percentages. *values displayed are mean (95% c.i.). Percentages and proportions were derived by excluding missing data from the variable. χ^2 test for difference. UGI, upper-gastrointestinal surgeon.

improvement in the recent years considered by this paper [35]. Our data contained details for the responsible consultant during the relevant hospital spell only. In a small number of cases, this may not reflect the surgeon who actually undertook the operation. Furthermore, consultants may have a diverse experience, particularly prior to subspecialist training and categorising consultants into subspecialties may not accurately reflect this experience, and limit the interpretation of the influence of subspecialisation.

These findings highlight the benefits that can come from emergency general surgery rotas that are staffed by consultants with a subspecialist interest in gastrointestinal surgery. Elective gastrointestinal practice encourages development of skills that are often applicable to the emergency setting. In particular we note that the utilisation of laparoscopic techniques is far higher amongst subspecialists. Laparoscopy has been shown to provide improved outcomes in the emergency setting for both upper [36,37] and lower gastrointestinal [38] procedures. The elective experience gained by colorectal and UGI subspecialists is clearly translating into improved outcomes for patients. We hypothesise that, over time, further subspecialisation within emergency surgery can continue to improve outcomes following emergency laparotomy and we would encourage further research into this area.

Ethical approval

No formal ethical approval was required for this entirely retrospective study. Caldicott approval was granted by individual NHS Foundation Trusts in the North of England prior to release of this anonymised patient data.

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None.

Author contribution

Leo R. Brown and Ross C. McLean: Conceptualisation, Methodology, Formal Analysis, Writing – Original Draft, Writing – Reviewing & Editing, Visualisation, Project Administration. **Daniel Perren:** Investigation, Data Curation, Writing – Reviewing & Editing, **Paul O'Loughlin and Iain JD. McCallum:** Conceptualisation, Writing – Reviewing & Editing, Supervision.

Conflicts of interest

None.

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Guarantor

Mr Leo R. Brown.

Data statement

Anonymised patient data was collected following Caldicott approval, granted by individual NHS Foundation Trusts in the North of England. Caldicott approval does not grant permission to share this data with any external sources.

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CRediT authorship contribution statement

Leo R. Brown: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Visualization, Project administration. **Ross C. McLean:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Visualization, Project administration. **Daniel Perren:** Investigation, Data curation, Writing - review & editing. **Paul O'Loughlin:** Conceptualization, Writing - review & editing, Supervision. **Iain JD. McCallum:** Conceptualization, Writing - review & editing, Supervision.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijsu.2019.01.010.

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