

Supplementary material for

**Variation in the rates of emergency surgery amongst emergency admissions to hospital
for common acute conditions**

Clinical panel defined inclusion and exclusion criteria

A clinical panel of 11 surgeons (four women) and one anaesthetist, based in 12 different UK centres across 11 different regions within the UK, that included clinicians with subspecialty interests was convened, and met twice.³⁹ A list of ICD10 codes for potential inclusion criteria and potential exclusion diagnoses was presented following the first facilitated meeting and discussed at the second (see supplementary Table 1). Each panellist privately rated the potential criteria. A relevant diagnosis for inclusion required at least 75% panel support and diagnoses forming exclusion criteria required at least 25% panel support. The consensus from the clinical panel with respect to changes to the inclusion and exclusion criteria are listed in Supplementary Table 2.

Clinical panel definition of Emergency Surgery

The panel also defined the procedures that represented 'emergency surgery' for patients in each cohort using a Delphi process. A list of Office of Population, Censuses and Surveys classification of surgical operations and procedures (OPCS) codes for potentially relevant procedures for each condition was drawn up and discussed at the first meeting. Panellists indicated privately whether each procedure constituted emergency surgery, and stated the number of days (e.g. three days, five days, seven days etc) within which surgery must be undertaken to count as 'emergency surgery'. Anonymised panel results were discussed at the second meeting before re-rating. A procedure was defined as constituting 'emergency surgery' if according to at least 50% of the panelists the specific procedure met that definition, and it was undertaken within the requisite number of days to meet the criteria for 'emergency surgery' according to the median stipulated across the members of the clinical panel (for agreed definition of ES, see results).

According to the consensus of the clinical panel, the defined time window for ES was within three days (hernia), seven days (appendicitis, cholelithiasis, intestinal obstruction), or any time within the index emergency admission (diverticular disease) (supplementary table 3).

Supplementary Table S1: List of ICD-10 codes considered for inclusion criteria

Population	ICD-10	Description
Appendicitis	K35	Acute appendicitis
	K35.2	Acute appendicitis with generalized peritonitis
	K35.3	Acute appendicitis with localized peritonitis
	K35.8	Acute appendicitis, other and unspecified
	K37	Unspecified appendicitis
Diverticular disease	K57.0	Diverticular disease of small intestine with perforation and abscess
	K57.1	Diverticular disease of small intestine without perforation or abscess
	K57.2	Diverticular disease of large intestine with perforation and abscess
	K57.3	Diverticular disease of large intestine without perforation or abscess
	K57.4	Diverticular disease of both small and large intestine with perforation and abscess
	K57.5	Diverticular disease of both small and large intestine without perforation or abscess
	K57.8	Diverticular disease of intestine, part unspecified, with perforation and abscess
	K57.9	Diverticular disease of intestine, part unspecified, without perforation or abscess
Cholelithiasis	K80.0	Calculus of gallbladder with acute cholecystitis
	K80.1	Calculus of gallbladder with other cholecystitis
	K80.2	Calculus of gallbladder without cholecystitis
	K80.3	Calculus of bile duct with cholangitis
	K80.4	Calculus of bile duct with cholecystitis
	K80.5	Calculus of bile duct without cholangitis or cholecystitis
	K80.8	Other cholelithiasis
Hernia	K40.0	Bilateral inguinal hernia, with obstruction, without gangrene
	K40.1	Bilateral inguinal hernia, with gangrene
	K40.2	Bilateral inguinal hernia, without obstruction or gangrene
	K40.3	Unilateral or unspecified inguinal hernia, with obstruction, without gangrene
	K40.4	Unilateral or unspecified inguinal hernia, with gangrene
	K40.9	Unilateral or unspecified inguinal hernia, without obstruction or gangrene
	K41.0	Bilateral femoral hernia, with obstruction, without gangrene
	K41.1	Bilateral femoral hernia, with gangrene
	K41.2	Bilateral femoral hernia, without obstruction or gangrene
	K41.3	Unilateral or unspecified femoral hernia, with obstruction, without gangrene
	K41.4	Unilateral or unspecified femoral hernia, with gangrene
	K41.9	Unilateral or unspecified femoral hernia, without obstruction or gangrene
	K42.0	Umbilical hernia with obstruction, without gangrene
	K42.1	Umbilical hernia with gangrene
	K42.9	Umbilical hernia without obstruction or gangrene
	K43.0	Incisional hernia with obstruction, without gangrene
	K43.1	Incisional hernia with gangrene
	K43.2	Incisional hernia without obstruction or gangrene
	K43.3	Parastomal hernia with obstruction, without gangrene
	K43.4	Parastomal hernia with gangrene
	K43.5	Parastomal hernia without obstruction or gangrene
K43.6	Other and unspecified ventral hernia with obstruction, without gangrene	
K43.7	Other and unspecified ventral hernia with gangrene	
K43.9	Other and unspecified ventral hernia without obstruction or gangrene	
Intestinal obstruction	K56.0	Paralytic ileus
	K56.1	Intussusception
	K56.2	Volvulus

	K56.3	Gallstone ileus
	K56.4	Other impaction of intestine
	K56.5	Intestinal adhesions [bands] with obstruction
	K56.6	Other and unspecified intestinal obstruction
	K56.7	Ileus, unspecified

Supplementary Table S2: Clinical panel-derived diagnostic inclusion and exclusion criteria

Inclusion criteria	Appendicitis	Cholelithiasis	Diverticular disease	Hernia	Intestinal obstruction*
Agreed for inclusion	All included	Calculus of gall bladder	Large intestine	Inguinal; Femoral; Umbilical; Ventral	Intestinal adhesions, Intussusception; Volvulus; Gallstone ileus; Other obstruction
Dropped from inclusion	None	Calculus of bile duct; Other cholelithiasis	Small intestine; Small and large intestine; Unspecified	Incisional; Parastomal	Paralytic ileus; Other impaction; Ileus, unspecified
Exclusion criteria					
Agreed for exclusion	Pregnancy; Appendiceal cancer			Pregnancy; Ischaemia; Cancer.	Colorectal cancer with metastases; Gynaecological cancer; Ischaemia
Dropped for exclusion					

* inclusion allowed for a relevant diagnosis in the second diagnosis field provided the main diagnosis was non-metastatic colorectal cancer.

Supplementary Table S3: Clinical panel-derived definitions of emergency surgery for each condition

	Appendicitis	Cholelithiasis	Diverticular disease	Hernia	Intestinal obstruction
Procedures defined as 'emergency surgery'	21 of 33	11 of 48	45 of 57	52 of 59	111 of 140
Common procedures excluded from definition of 'emergency surgery'	*Unspecified other excision of appendix	Endoscopic sphincterotomy	Image controlled percutaneous drainage	none	none
Threshold for a procedure in the index admission to be 'emergency surgery'	7 days	7 days	Any time	3 days	7 days
Threshold for a procedure in a readmission to be 'emergency surgery'	7 days	7 days	14 days	3 days	7 days
Emergency surgery: n (% of cohort)	249,165 (91.4)	52,543 (21.5)	18,085 (12.8)	62,578 (57.5)	41,656 (29.7)

Supplementary table S4: Inclusion and exclusion criteria for emergency admissions to 136 acute NHS Trusts in England April 2010-December 2019

	Appendicitis	Cholelithiasis	Diverticular disease	Hernia	Intestinal obstruction
Meet inclusion criteria: n	308,915	367,497	200,816	147,122	238,097
Exclusions: n (%)					
No episode with a consultant surgeon	8,582 (2.8%)	56,913 (15.5%)	26,606 (13.2%)	9,457 (6.4%)	34,475 (14.5%)
No eligible diagnosis in the first two episodes	1,492 (0.5%)	5,593 (1.5%)	5,501 (2.7%)	1,761 (1.2%)	7,208 (3.0%)
Not admitted through A&E or GP	21,053 (6.8%)	21,637 (5.9%)	12,182 (6.1%)	11,477 (7.8%)	13,595 (5.7%)
Clinical panel exclusion criteria	1,443 (0.5%)	n/a	n/a	7,574 (5.1%)	10,512 (4.4%)
Missing discharge data	351 (0.1%)	274 (0.1%)	146 (0.1%)	115 (0.1%)	340 (0.1%)
Ineligible hospital	1,007 (0.3%)	1,648 (0.4%)	768 (0.4%)	490 (0.3%)	911 (0.4%)
Transfer between hospitals before index episode	634 (0.2%)	588 (0.2%)	406 (0.2%)	173 (0.1%)	503 (0.2%)
Other admission meeting inclusion criteria in previous 12 months	3,572 (1.2%)	38,812 (10.6%)	15,544 (7.7%)	7,908 (5.4%)	31,686 (13.3%)
Emergency surgery prior to index episode	2,519 (0.8%)	406 (0.1%)	574 (0.3%)	842 (0.6%)	1,123 (0.5%)
Included in cohort: n	268,253	241,626	139,090	107,325	137,744
Emergency surgery: n (%)					
Yes	247,475 (92.3%)	52,014 (21.5%)	15,255 (11.0%)	62,150 (57.9%)	41,144 (29.9%)
No	20,778 (7.7%)	189,612 (78.5%)	123,835 (89.0%)	45,175 (42.1%)	96,600 (70.1%)

Supplementary Table S5: Diagnostic subcategories

Population	ICD-10	Description	N (%)
Appendicitis	K35	Acute appendicitis	14,810 (5.5)
	K35.2	Acute appendicitis with generalized peritonitis	10,482 (3.9)
	K35.3	Acute appendicitis with localized peritonitis	59,465 (22.2)
	K35.8	Acute appendicitis, other and unspecified	147,103 (54.8)
	K37	Unspecified appendicitis	36,393 (13.6)
Diverticular disease	K57.2	Diverticular disease of large intestine with perforation and abscess	32,741 (23.8)
	K57.3	Diverticular disease of large intestine without perforation or abscess	106,349 (77.2)
Cholelithiasis	K80.0	Calculus of gallbladder with acute cholecystitis	87,021 (36.0)
	K80.1	Calculus of gallbladder with other cholecystitis	67,697 (28.0)
	K80.2	Calculus of gallbladder without cholecystitis	86,908 (36.0)
Hernia	K40.0	Bilateral inguinal hernia, with obstruction, without gangrene	962 (0.1)
	K40.1	Bilateral inguinal hernia, with gangrene	52 (0.0)
	K40.2	Bilateral inguinal hernia, without obstruction or gangrene	2,024 (1.9)
	K40.3	Unilateral or unspecified inguinal hernia, with obstruction, without gangrene	17,274 (16.1)
	K40.4	Unilateral or unspecified inguinal hernia, with gangrene	738 (0.7)
	K40.9	Unilateral or unspecified inguinal hernia, without obstruction or gangrene	30,522 (28.4)
	K41.0	Bilateral femoral hernia, with obstruction, without gangrene	263 (0.2)
	K41.1	Bilateral femoral hernia, with gangrene	37 (0.0)
	K41.2	Bilateral femoral hernia, without obstruction or gangrene	56 (0.1)
	K41.3	Unilateral or unspecified femoral hernia, with obstruction, without gangrene	8,517 (7.9)
	K41.4	Unilateral or unspecified femoral hernia, with gangrene	1,150 (1.1)
	K41.9	Unilateral or unspecified femoral hernia, without obstruction or gangrene	3,498 (3.3)
	K42.0	Umbilical hernia with obstruction, without gangrene	18,387 (17.1)
	K42.1	Umbilical hernia with gangrene	1,248 (1.2)
	K42.9	Umbilical hernia without obstruction or gangrene	20,417 (19.0)
	K43.6	Other and unspecified ventral hernia with obstruction, without gangrene	2,083 (1.9)
	K43.7	Other and unspecified ventral hernia with gangrene	97 (0.1)
Intestinal obstruction	K56.1	Intussusception	1,481 (1.1)
	K56.2	Volvulus	16,277 (11.8)
	K56.3	Gallstone ileus	2,045 (1.5)
	K56.5	Intestinal adhesions [bands] with obstruction	47,737 (34.7)
	K56.6	Other and unspecified intestinal obstruction	70,204 (51.0)

Supplementary Table S6: Characteristics of emergency surgery

	Appendicitis (n=247,475)	Cholelithiasis (n=52,014)	Diverticular disease (n=15,255)	Hernia (n=62,150)	Intestinal obstruction (n=41,144)
Day of surgery: median (IQR)	1 (0;1)	2 (1;4)	1 (0;2)	0 (0;1)	1 (0;3)
Five most common main procedures: procedure [OPCS code] and n (%)	<p>Emergency excision of abnormal appendix NEC [H012] 162,584 (65.7)</p> <p>Unspecified other excision of appendix [H029] 42,864 (17.3)</p> <p>Emergency excision of abnormal appendix and drainage HFQ [H011] 25,580 (10.3)</p> <p>Unspecified emergency excision of appendix [H019] 9,086 (3.7)</p> <p>Emergency excision of normal appendix [H013] 3,472 (1.4)</p>	<p>Total cholecystectomy NEC [J183] 44,614 (85.8)</p> <p>Percutaneous drainage of gall bladder [J241] 2,354 (4.5)</p> <p>Partial cholecystectomy NEC [J185] 1,755 (3.4)</p> <p>Drainage of gall bladder [J212] 1,365 (2.6)</p> <p>Total cholecystectomy and exploration of common bile duct [J182] 1,281 (2.5)</p>	<p>Rectosigmoidectomy and closure of rectal stump and exteriorisation of bowel [H335] 8,883 (58.2)</p> <p>Irrigation of peritoneal cavity [T463] 1,288 (8.4)</p> <p>Sigmoid colectomy and exteriorisation of bowel NEC [H105] 1,044 (6.8)</p> <p>Anterior resection of rectum and exteriorisation of bowel [H336] 497 (3.3)</p> <p>Loop colostomy [H151] 360 (2.4)</p>	<p>Primary repair of inguinal hernia using insert of prosthetic material [T202] 18,993 (30.6)</p> <p>Repair of umbilical hernia using sutures [T243] 12,349 (19.9)</p> <p>Repair of umbilical hernia using insert of prosthetic material [T242] 8,386 (13.5)</p> <p>Primary repair of femoral hernia using sutures [T223] 6,304 (10.1)</p> <p>Primary repair of femoral hernia using insert of prosthetic material [T222] 4,644 (7.5)</p>	<p>Freeing of adhesions of peritoneum [T413] 12,740 (31.0)</p> <p>Ileectomy and anastomosis of ileum to ileum [G693] 3,522 (8.6)</p> <p>Endoscopic division of adhesions of peritoneum [T423] 2,978 (7.2)</p> <p>Division of band of peritoneum [T412] 2,133 (5.2)</p> <p>Freeing of extensive adhesions of peritoneum [T415] 1,816 (4.4)</p>

Table S7: Adjusted odds ratios for association between SCARF frailty index and receipt of ES for diverticular disease and intestinal obstruction at each level of the Charlson comorbidity index

	Appendicitis (n=268,253)	Cholelithiasis (n=241,626)	Diverticular disease (n=139,090)	Hernia (n=107,325)	Intestinal obstruction (n=137,744)
Charlson comorbidity index: none					
Frailty index:					
Fit	-	-	reference	-	reference
Mild			2.24 (2.10, 2.38)		1.62 (1.56, 1.69)
Moderate			5.07 (4.55, 5.64)		2.49 (2.33, 2.66)
Severe			7.46 (6.34, 8.38)		2.32 (2.10, 2.56)
Charlson comorbidity index: 1					
Frailty index:					
Fit	-	-	reference	-	reference
Mild			1.57 (1.42, 1.73)		1.18 (1.11, 1.24)
Moderate			2.55 (2.26, 2.87)		1.57 (1.47, 1.68)
Severe			3.14 (2.67, 3.70)		1.87 (1.71, 2.06)
Charlson comorbidity index: 2					
Frailty index:					
Fit	-	-	reference	-	reference
Mild			0.93 (0.71, 1.21)		0.89 (0.79, 1.00)
Moderate			1.13 (0.86, 1.47)		1.04 (0.92, 1.17)
Severe			1.38 (1.03, 1.86)		1.23 (1.07, 1.42)
Charlson comorbidity index: 3 or more					
Frailty index:					
Fit	-	-	reference	-	reference
Mild			0.72 (0.33, 1.54)		0.73 (0.51, 1.04)
Moderate			0.86 (0.41, 1.80)		0.67 (0.48, 0.95)
Severe			0.71 (0.33, 1.51)		0.72 (0.50, 1.03)