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12. Royal College of Surgeons of England, Age UK. *Access all ages: Assessing the impact of age on access to surgical treatment*. London: RCS; 2012.
13. Royal College of Surgeons of England, Age UK. *Access all ages 2: exploring variations in access to surgery among older patients*. London: RCS; 2014.
14. CholeS Study Group. Population-based cohort study of variation in the use of emergency cholecystectomy for benign gallbladder diseases. *British Journal of Surgery* 2016;103:1716-1726.
15. Emergency Surgery or Not (ESORT). Study protocol. Available from: <https://www.lshtm.ac.uk/media/38711> [accessed May 6th, 2021]
16. Emergency Surgery or Not (ESORT). Public and Patient Involvement (PPI). Summary note. Available from: <https://www.lshtm.ac.uk/media/42971> [accessed May 6th, 2021]
17. Emergency Surgery or Not (ESORT). Clinical panel. Summary note. Available from: <https://www.lshtm.ac.uk/media/39151> [accessed May 6th, 2021]
18. Armitage JN, van der Meulen JH. Identifying co-morbidity in surgical patients using administrative data with the Royal College of Surgeons Charlson Score. *Br J Surg* 2010;97(5):772-81. doi: 10.1002/bjs.6930.
19. Jauhari Y, Gannon MR, Dodwell D, et al. Construction of the secondary care administrative records frailty (SCARF) index and validation on older women with operable invasive breast cancer in England and Wales: a cohort study. *BMJ Open* 2020;10:e035395. doi: 10.1136/bmjopen-2019-035395.
20. National Institute for Health and Care Excellence (NICE). *Gallstone Disease: Diagnosis and Management*. Clinical Guideline CG188; 2014. <https://www.nice.org.uk/guidance/cg188> [accessed May 6, 2021].
21. Wu XD, Tian X, Liu MM, Wu L, Zhao S, Zhao L. Meta-analysis comparing early versus delayed laparoscopic cholecystectomy for acute cholecystitis. *Br J Surg* 2015; 102: 1302–1313

22. Bamber JR, Stephens TJ, Cromwell DA, et al. Effectiveness of a quality improvement collaborative in reducing time to surgery for patients requiring emergency cholecystectomy. *BJS Open*. 2019;3(6):802-811. Published 2019 Oct 8. doi:10.1002/bjs5.50221
23. Peacock O, Bassett MG, Kuryba A, Walker K, Davies E, Anderson I, Vohra RS; National Emergency Laparotomy Audit (NELA) Project Team. Thirty-day mortality in patients undergoing laparotomy for small bowel obstruction. *Br J Surg*. 2018 Jul;105(8):1006-1013. doi: 10.1002/bjs.10812. Epub 2018 Mar 30. PMID: 29603126.
24. Management of Acutely Symptomatic Hernias (MASH) study protocol. Protocol V2 dated 10.12.19 clean\_hernia.pdf. Available from Management of Acutely Symptomatic Hernias (MASH) study | (britishherniasociety.org)
25. Hwang MJ, Bhangu A, Webster CE, Bowley DM, Gannon MX, Karandikar SS. Unintended consequences of policy change to watchful waiting for asymptomatic inguinal hernias. *Ann R Coll Surg Engl*. 2014 Jul;96(5):343-7. doi: 10.1308/003588414X13946184902000.
26. Orchard MR, Wright JA, Kelly A, McCabe DJ, Hewes J. The impact of healthcare rationing on elective and emergency hernia repair. *Hernia*. 2016 Jun;20(3):405-9. doi: 10.1007/s10029-015-1441-y.
27. Schultz, JK, Yaqub, S., Wallon, C et al (2015). Laparoscopic lavage vs primary resection for acute perforated diverticulitis: The SCANDIV randomized clinical trial. *JAMA - Journal of the American Medical Association*. <https://doi.org/10.1001/jama.2015.12076>
28. Schultz, J. K., Wallon, C., Blecic, L. et al (2017). One-year results of the SCANDIV randomized clinical trial of laparoscopic lavage versus primary resection for acute perforated diverticulitis. *British Journal of Surgery*. <https://doi.org/10.1002/bjs.10567>
29. Thornell, A., Angenete, E., Bisgaard, T. et al (2016). Laparoscopic lavage for perforated diverticulitis with purulent peritonitis. *Annals of Internal Medicine*. <https://doi.org/10.7326/M15-1210>
30. Paterson, HM, Arnott, ID., Nicholls, RJ. et al. (2015). Diverticular disease in Scotland: 2000-2010. *Colorectal Disease*, 17(4), 329-334. <https://doi.org/10.1111/codi.12811>
31. National Institute for Health and Care Excellence *Guidance 147, Management of Diverticular Disease*. <https://pathways.nice.org.uk/pathways/diverticular-disease> [accessed May 6, 2021].
32. Markar SR, Vidal-Diez A, Holt PJ, Karthikesalingam A, Hanna GB. An International Comparison of the Management of Gastrointestinal Surgical Emergencies in Octogenarians-England Versus United

States: A National Population-based Cohort Study. *Ann Surg.* 2021 May 1;273(5):924-932. doi: 10.1097/SLA.0000000000003396. PMID: 31188204.

33. Humes DJ, Solaymani-Dodaran M, Fleming KM, Simpson J, Spiller RC, West J (2009). A population-based study of perforated diverticular disease incidence and associated mortality. *Gastroenterology*, 136(4):1198 -1205. <https://doi.org/10.1053/j.gastro.2008.12.054>

34. HAREM Study: Had Appendicitis and Resolved/Recurred Emergency Morbidity/Mortality. Study protocol. Available from: COVID Research group — Royal College of Surgeons ([rcseng.ac.uk](http://rcseng.ac.uk)) [accessed May 6, 2021]

## Tables and Figures

**Table 1: Patient characteristics of the five cohorts**

	<b>Appendicitis (n=268,253)</b>	<b>Cholelithiasis (n=241,626)</b>	<b>Diverticular disease (n=139,090)</b>	<b>Hernia (n=107,325)</b>	<b>Intestinal obstruction (n=137,744)</b>
Age category: n (%)					
Under 25	63,405 (23.6)	12,137 (5.0)	310 (0.2)	2,282 (2.1)	2,251 (1.6)
25-29	37,585 (14.0)	15,339 (6.4)	1,077 (0.8)	3,159 (2.9)	2,352 (1.7)
30-34	31,391 (11.7)	16,480 (6.8)	2,471 (1.8)	4,021 (3.8)	2,807 (2.0)
35-39	25,494 (9.5)	16,121 (6.7)	4,659 (3.4)	4,760 (4.4)	3,520 (2.6)
40-44	21,668 (8.1)	17,783 (7.4)	7,595 (5.5)	6,137 (5.7)	4,770 (3.5)
45-49	19,799 (7.4)	20,627 (8.5)	11,482 (8.3)	7,832 (7.3)	6,850 (5.0)
50-54	17,431 (6.5)	21,133 (8.8)	14,021 (10.1)	8,295 (7.7)	8,578 (6.2)
55-59	13,844 (5.2)	19,783 (8.2)	14,077 (10.1)	8,014 (7.5)	9,724 (7.1)
60-64	11,158 (4.2)	18,907 (7.8)	13,681 (9.8)	8,406 (7.8)	11,612 (8.4)
65-69	9,464 (3.5)	19,799 (8.2)	14,339 (10.3)	9,241 (8.6)	14,462 (10.5)
70-74	6,992 (2.6)	18,969 (7.9)	14,677 (10.6)	10,414 (9.7)	16,425 (11.9)
75-79	4,729 (1.8)	16,863 (7.0)	14,106 (10.1)	10,859 (10.1)	17,330 (12.6)
80-84	3,019 (1.1)	14,179 (5.9)	12,893 (9.3)	10,881 (10.1)	16,686 (12.1)
85-89	1,606 (0.6)	9,061 (3.8)	9,149 (6.6)	8,276 (7.7)	12,697 (9.2)
90 and over	668 (0.3)	4,445 (1.8)	4,553 (3.3)	4,748 (4.4)	7,680 (5.6)
Sex: n (%)					
Female	123,520 (46.1)	163,219 (67.6)	81,994 (59.0)	37,776 (35.2)	72,237 (52.4)
Male	144,720 (54.0)	78,398 (32.5)	57,093 (41.1)	69,545 (64.8)	65,504 (47.6)
Missing	13	9	3	4	3
Ethnicity: n (%)					
Black/Black mixed	6,401 (2.7)	4,761 (2.1)	2,132 (1.6)	2,647 (2.7)	3,433 (2.6)
Asian/Asian mixed	12,721 (5.3)	11,359 (5.0)	2,421 (1.8)	3,621 (3.6)	4,462 (3.4)
White	211,433 (88.0)	207,696 (90.7)	126,246 (95.2)	91,651 (91.7)	122,152 (92.3)
Chinese and other	9,764 (3.6)	5,105 (2.2)	1,876 (1.4)	1,989 (2.0)	2,361 (1.8)
Missing	27,934	12,705	6,415	7,417	5,336
Deprivation quintile:					
Most deprived	53,835 (20.4)	56,610 (23.7)	25,024 (18.1)	23,033 (21.7)	24,167 (17.7)
2	54,385 (20.6)	50,779 (21.2)	27,325 (19.8)	22,094 (20.8)	26,253 (19.3)
3	53,351 (20.2)	48,313 (20.2)	29,119 (21.1)	21,908 (20.6)	28,914 (21.2)
4	51,739 (19.6)	44,492 (18.6)	29,270 (21.2)	20,646 (19.4)	28,796 (21.1)
Least deprived	50,564 (19.2)	39,067 (16.3)	27,180 (19.7)	18,614 (17.5)	28,092 (20.6)
Missing	4,379	2,365	1,172	1,030	1,522
Comorbidity: n (%)					
None	222,935 (83.1)	157,866 (65.3)	83,367 (59.9)	66,156 (61.6)	72,308 (52.5)
1	39,727 (14.8)	62,343 (25.8)	39,661 (28.5)	29,847 (27.8)	43,582 (31.6)
2	4,753 (1.8)	17,108 (7.1)	12,697 (9.1)	9,013 (8.4)	17,129 (12.4)
3 or more	838 (0.3)	4,309 (1.8)	3,365 (2.4)	2,309 (2.2)	4,725 (3.4)
Frailty index: n (%)					
Fit	221,900 (82.7)	157,866 (65.3)	72,225 (51.9)	57,435 (53.5)	62,989 (45.7)
Mild frailty	38,612 (14.4)	62,343 (25.8)	44,551 (32.0)	32,973 (30.7)	45,428 (33.0)
Moderate frailty	6,200 (2.3)	17,108 (7.1)	16,163 (11.6)	12,416 (11.6)	20,497 (14.9)
Severe frailty	1,541 (0.6)	4,309 (1.8)	6,151 (4.4)	4,501 (4.2)	8,830 (6.4)



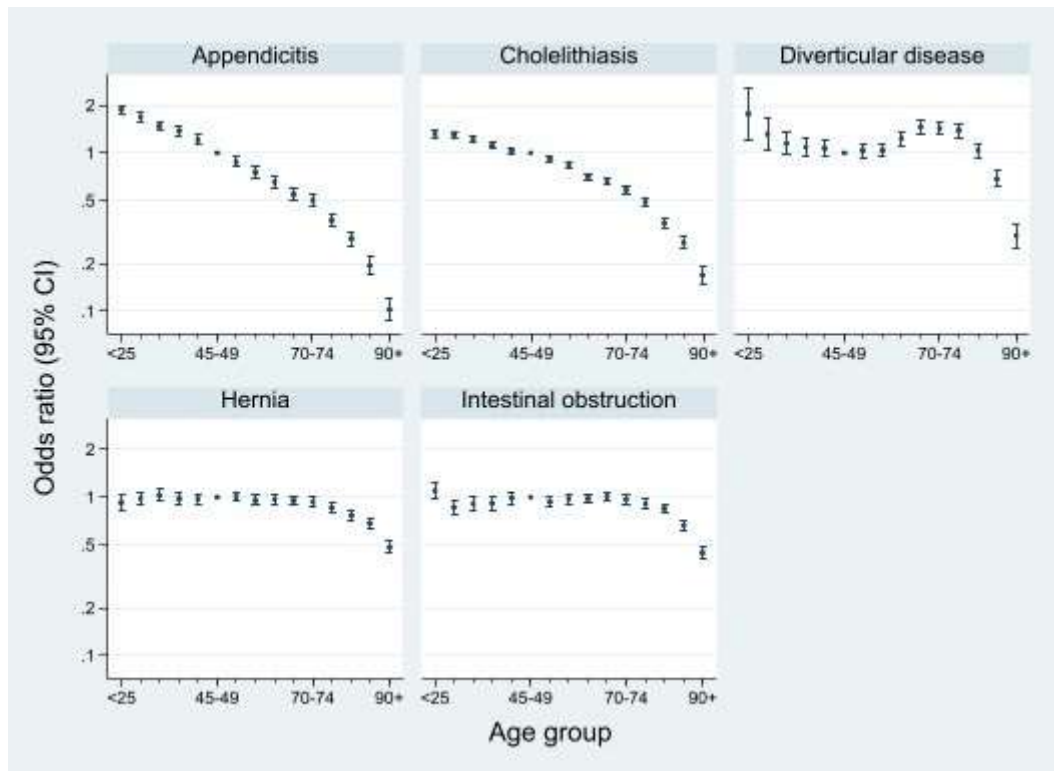
**Table 2: Percentage of emergency admissions receiving ES according to patient characteristics**

	<b>Appendicitis (n=268,253)</b>	<b>Cholelithiasis (n=241,626)</b>	<b>Diverticular disease (n=139,090)</b>	<b>Hernia (n=107,325)</b>	<b>Intestinal obstruction (n=137,744)</b>
Age category:					
Under 25	99.0	26.4	14.5	50.2	32.5
25-29	94.5	27.4	13.0	51.9	27.3
30-34	94.0	26.3	11.5	53.7	27.8
35-39	93.8	25.6	10.9	53.6	29.4
40-44	93.1	25.0	10.9	55.6	30.9
45-49	92.0	24.8	9.9	57.2	31.4
50-54	91.3	24.1	9.6	58.4	30.2
55-59	89.9	23.0	9.7	58.5	31.1
60-64	88.4	20.7	11.4	59.4	31.2
65-69	86.7	19.9	13.1	61.4	31.7
70-74	85.3	18.2	13.5	60.6	31.8
75-79	80.5	15.8	12.9	60.0	30.9
80-84	75.5	12.4	11.3	59.2	30.5
85-89	67.3	9.8	8.1	57.8	26.3
90 and over	50.8	6.8	4.2	53.0	19.6
Sex:					
Female	91.7	22.6	10.3	65.5	32.6
Male	92.8	19.3	12.0	53.8	26.8
Comorbidity index:					
None	93.1	23.3	11.4	59.1	31.6
1	89.9	19.7	10.9	58.0	29.9
2	78.1	14.9	9.2	52.6	24.8
3 or more	65.0	10.1	8.1	45.2	21.0
Frailty index:					
Fit	93.2	22.8	8.3	57.2	28.2
Mild frailty	89.4	20.5	12.2	59.1	30.6
Moderate frailty	81.3	17.3	16.2	58.5	32.2
Severe frailty	73.0	15.6	19.4	56.5	32.5

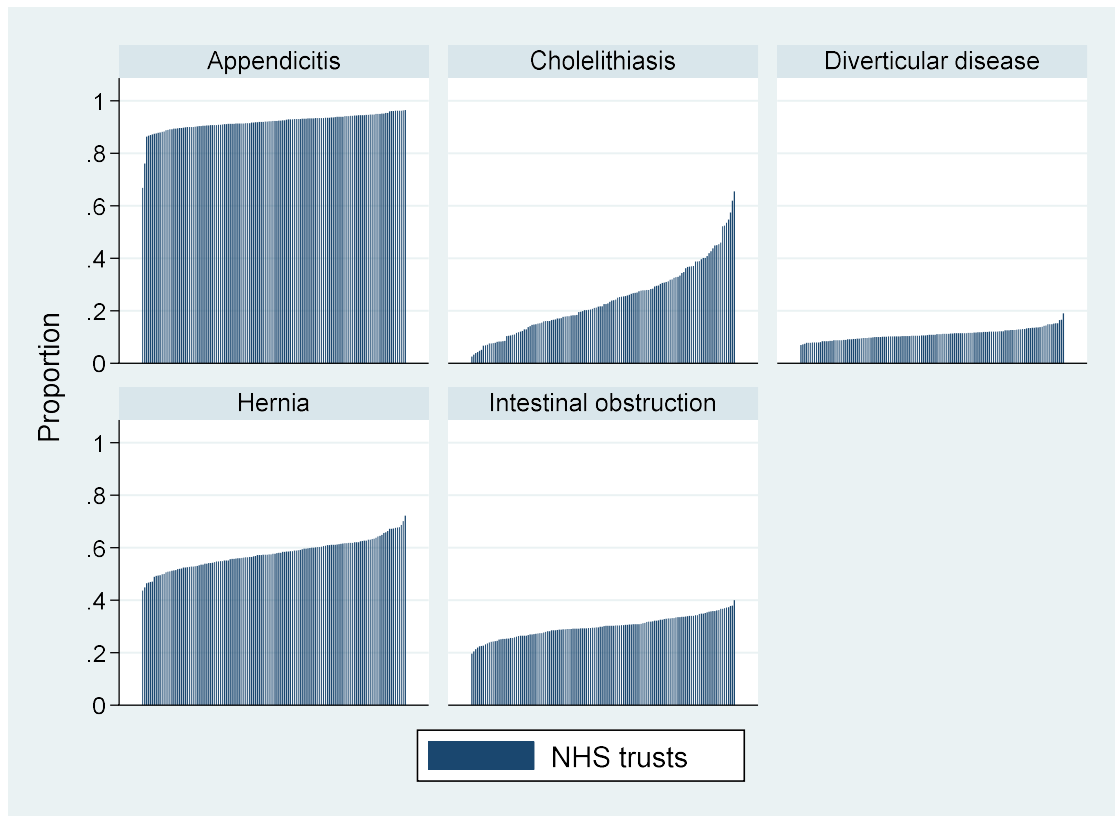
**Table 3: Emergency admissions receiving ES according to patient characteristics, with adjusted odds ratios**

	<b>Appendicitis (n=268,253)</b>	<b>Cholelithiasis (n=241,626)</b>	<b>Diverticular disease (n=139,090)</b>	<b>Hernia (n=107,325)</b>	<b>Intestinal obstruction (n=137,744)</b>
Age category:					
Under 25	2.00 (1.87, 2.13)	1.33 (1.25, 1.40)	1.76 (1.20, 2.60)	0.93 (0.84, 1.04)	1.11 (1.00, 1.25)
25-29	1.79 (1.67, 1.92)	1.30 (1.24, 1.37)	1.33 (1.06, 1.66)	0.99 (0.90, 1.09)	0.86 (0.77, 0.96)
30-34	1.54 (1.43, 1.66)	1.22 (1.15, 1.28)	1.14 (0.97, 1.34)	1.03 (0.94, 1.12)	0.91 (0.82, 1.01)
35-39	1.44 (1.34, 1.56)	1.12 (1.06, 1.18)	1.09 (0.96, 1.24)	0.98 (0.90, 1.06)	0.91 (0.82, 1.00)
40-44	1.23 (1.14, 1.32)	1.03 (0.98, 1.09)	1.08 (0.97, 1.21)	0.97 (0.90, 1.05)	0.99 (0.91, 1.08)
45-49	reference	reference	reference	reference	reference
50-54	0.87 (0.80, 0.94)	0.92 (0.87, 0.96)	1.04 (0.94, 1.14)	1.01 (0.94, 1.08)	0.94 (0.87, 1.01)
55-59	0.73 (0.68, 0.79)	0.84 (0.80, 0.89)	1.05 (0.96, 1.16)	0.97 (0.90, 1.04)	0.98 (0.91, 1.06)
60-64	0.62 (0.57, 0.68)	0.71 (0.67, 0.74)	1.25 (1.13, 1.37)	0.97 (0.90, 1.04)	0.97 (0.91, 1.04)
65-69	0.52 (0.48, 0.57)	0.66 (0.63, 0.70)	1.48 (1.34, 1.62)	0.96 (0.89, 1.03)	1.01 (0.95, 1.08)
70-74	0.47 (0.43, 0.51)	0.59 (0.56, 0.62)	1.45 (1.32, 1.60)	0.94 (0.87, 1.01)	0.96 (0.90, 1.03)
75-79	0.34 (0.31, 0.38)	0.49 (0.46, 0.52)	1.40 (1.27, 1.54)	0.87 (0.81, 0.93)	0.91 (0.85, 0.97)
80-84	0.26 (0.24, 0.29)	0.36 (0.34, 0.39)	1.05 (0.94, 1.16)	0.78 (0.72, 0.84)	0.84 (0.79, 0.90)
85-89	0.17 (0.15, 0.19)	0.27 (0.25, 0.29)	0.67 (0.59, 0.75)	0.70 (0.64, 0.75)	0.66 (0.61, 0.71)
90 and over	0.09 (0.07, 0.10)	0.17 (0.15, 0.19)	0.29 (0.24, 0.35)	0.47 (0.43, 0.52)	0.44 (0.40, 0.48)
Sex:					
Female	0.95 (0.93-0.98)	1.18 (1.15-1.21)	0.97 (0.93, 1.02)	0.98 (0.95-1.02)	1.27 (1.24, 1.30)
Male	reference	reference	reference	reference	reference
Comorbidity:					
None	reference	reference	reference	reference	reference
1	0.86 (0.82, 0.90)	0.87 (0.84, 0.89)	0.71 (0.68, 0.75)	0.88 (0.85, 0.91)	0.77 (0.75, 0.80)
2	0.54 (0.50, 0.59)	0.67 (0.64, 0.71)	0.44 (0.41, 0.48)	0.71 (0.66, 0.75)	0.56 (0.54, 0.59)
3 or more	0.37 (0.31, 0.43)	0.44 (0.39, 0.49)	0.33 (0.28, 0.38)	0.57 (0.51, 0.63)	0.42 (0.39, 0.46)
Frailty index:					
Fit	reference	reference	reference	reference	reference
Mild	0.99 (0.94, 1.03)	1.11 (1.08, 1.15)	2.00 (1.90, 2.11)	1.01 (0.97, 1.05)	1.42 (1.38, 1.47)
Moderate	0.89 (0.81, 0.97)	1.22 (1.16, 1.28)	3.29 (3.06, 3.54)	0.93 (0.88, 0.99)	1.84 (1.77, 1.92)
Severe	0.80 (0.70, 0.92)	1.34 (1.23, 1.45)	3.84 (3.48, 4.24)	0.72 (0.66, 0.78)	1.98 (1.87, 2.10)

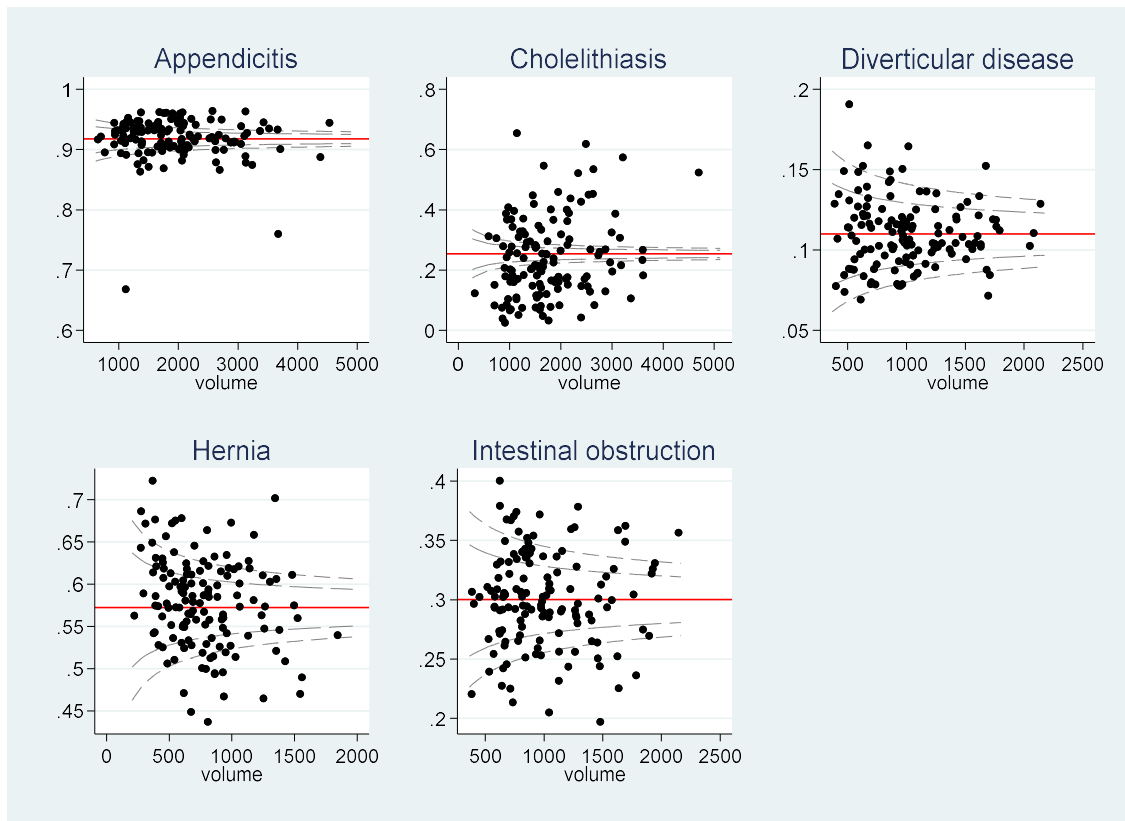
Figure 1: Association between age group and receiving ES, with adjusted odds ratios (95% CIs) in comparison with 45-49 year olds.



**Figure 2: Variation in rates of emergency surgery in emergency admissions to 136 acute NHS Trusts in England April 2010-December 2019**



**Figure 3: Funnel plots of variation in rates of emergency surgery in 136 acute NHS Trusts in England April 2010-December 2019**



Control limits are at 95% (long dash) and 99.8% (short dash).

**Supplementary tables (provided separately)**

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

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

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

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

Supplementary Table S5: Frequency of diagnostic subcategories for each condition

Supplementary Table S6: Characteristics of emergency surgery for each condition

Supplementary 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