



Hospital- and surgeon-level volumes for rectal cancer surgery in England and implications for Wales

NBOCA: Short Report

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Executive Summary

There has been an increasing focus on the relationship between rectal cancer surgery volumes or, in other words, the average number of surgical procedures carried out per year, and outcomes. This has coincided with the publication of the new National Institute for Health and Care Excellence (NICE) guidelines recommending minimum thresholds for both hospital and surgeon volumes. However, the quality of most of the available evidence was deemed to be poor with significant methodological limitations, and a paucity of evidence for the United Kingdom (UK).

The investigation described in this report builds on preliminary work exploring hospital and surgeon rectal cancer surgery volumes within England. In particular, we tried to ensure that the hospitals' procedure volume and the identity of the responsible surgeon are established as robustly as possible through linkage of National Bowel Cancer Audit (NBOCA) data to other data sources for validation of this information. In addition, we explore differences between patients, hospitals, and surgeons by volume of surgery performed.

The results show that more robust reporting of volumes can be achieved by using the other data sources (Hospital Episode Statistics and General Medical Council data) to improve case ascertainment and accuracy. Most hospitals are performing above the threshold of 10 rectal cancer resections per year recommended by NICE. However, a significant proportion of surgeons do not meet the recommended threshold of 5 rectal cancer resections per year. In addition, some clear case-mix and clinical differences exist between low- and high-volume hospitals and surgeons.

This report will inform and facilitate further work exploring the relationship between rectal cancer surgery volume and outcome, including appropriate risk-adjustment. It has highlighted areas for additional improvement, for example, the need for robust data on the identity of the surgeon responsible for a procedure in Wales and the capacity to record multiple consultant surgeons.

Recommendations

No.	Recommendation	Intended audience for recommendation	Evidence in the report which underpins the recommendation	Guidance available (for example, NICE guideline)
Rec 1	Hospitals should review their results for rectal cancer surgery volumes (published for the first time as a performance indicator for patients undergoing major resection between 1 April 2019 and 31 March 2020) and evaluate their current practice in line with the new NICE guidelines.	Individual providers Commissioners	Page 10-11. NICE guidelines recommend at least 10 rectal cancer resections per year per hospital. There are a handful of hospital sites that do not meet this threshold.	NICE Guideline NG151 – Colorectal cancer (update) [F1] Surgical volumes and outcomes for rectal cancer (January 2020) NICE Guideline NG151 - Colorectal Cancer (January 2020)
Rec 2	Explore how best to appropriately utilise and monitor surgeon-level rectal cancer surgery volumes (i.e. the potential for reporting surgeon-level rectal cancer volumes back to individual hospitals to inform service structure).	Individual providers Individual surgeons Commissioners	Page 11. NICE guidelines recommend at least 5 rectal cancer resections per year per surgeon. 44% of surgeons are not currently meeting this requirement.	NICE Guideline NG151 – Colorectal cancer (update) [F1] Surgical volumes and outcomes for rectal cancer (January 2020) NICE Guideline NG151 - Colorectal Cancer (January 2020)
Rec 3	Welsh representatives to explore how robust Welsh surgeon-level data (from both NBOCA and PEDW) can be obtained, validated and fed back in a similar way.	Individual Welsh MDTs/providers Welsh representatives Welsh Government	Page 7. NBOCA do not have Welsh surgeon-level data currently precluding any evaluation of this.	Not applicable

Rec 4	Hospitals should begin to enter multiple consultant surgeons where appropriate to indicate dual consultant operating using the new NBOCA data entry item.	Individual providers	Page 11. NBOCA are aware of the increasing uptake of dual consultant operating, particularly following recommendations during the pandemic.	Not applicable
Rec 5	Hospitals are encouraged to improve data completion for tumour height above anal verge and body mass index in order to improve the capture of the complexity of rectal cancer surgery.	Individual providers	Page 12. Data completeness and quality for these data items is poor. Better capture of these items would enable improved understanding of the complexity of rectal cancer surgery.	Not applicable

Introduction

A relationship between surgical volume and outcomes was first described in 1979 by Luft *et al.*[1] This work examined mortality rates for 12 surgical procedures to determine whether a hospital's average number of surgical procedures carried out per year was associated with surgical mortality. The results varied according to which operation was performed. Procedures such as open heart and vascular surgery showed significantly reduced mortality with a procedural volume above 200. Other procedures such as colectomy (removal of part of the bowel) and total hip replacement demonstrated a flatter mortality curve with hospitals performing 50-100 procedures having comparable mortality rates to the highest volume hospitals. Some procedures, for example cholecystectomy (removal of the gallbladder), showed no relationship at all.

Over time, an increasing body of evidence has shown better post-operative and long-term oncological outcomes for hospitals performing high volumes of the more complex surgical procedures including oesophagectomy (removal of all/ part of the oesophagus), gastrectomy (removal of all/ part of the stomach), pancreatectomy (removal of all/ part of the pancreas), and hepatectomy (removal of part of the liver).[2 3] As a result, specialisation of these procedures to high-volume hospitals has occurred via hub-and-spoke models.[4] The specialisation of oesophago-gastric cancer care in England coincided with a reduction in post-operative mortality from 7.4% to 2.5%, although this could not be explained by volume increases alone.[5]

Management of rectal cancer is challenging due to the complexity of potential treatment options including neo-adjuvant therapy, surgical anatomy within the constraints of the rigid bony pelvis and associated structures, and need for shared decision-making with patients to ensure good functional outcomes. Achieving good oncological outcomes whilst minimising morbidity, and avoiding compromise to sexual and urinary function due to damage to important autonomic nerves, is difficult to achieve. One of the other principal arguments for specialisation is to ensure salvage in the event of complications. The experience required is not just surgical but also experienced interventional radiology and endoscopy services, and would require careful co-ordination.

In addition, the overall management of rectal cancer is becoming increasingly complex with multidisciplinary input required to make appropriate decisions about suitability for neo-adjuvant and adjuvant therapies, local excision, "watch-and-wait" strategies, surgical approach and avoidance or need for permanent stoma. There has been increasing uptake of robotic surgery for rectal cancer resections.

There are other considerations to be made with regards to the specialisation of rectal cancer surgery. The patient perspective is particularly important as we increasingly help patients to understand the trade-offs involved in seeking specialist care (entailing travelling) versus local treatment (which might be less specialised). However, patients have previously expressed a willingness to travel for high quality care and outcomes.[6] There also needs to be consideration of workforce and training opportunities, with good experience in high volume centres and exposure to salvage surgery important for trainees.

This complexity clearly calls for decision-making in units with breadth of experience and access to multiple tailored patient pathways, and yet evidence for the specialisation of rectal cancer

management remains conflicting.[7] A recent review of available evidence was undertaken by the National Institute for Health and Care Excellence (NICE).[8] Significant methodological limitations were present within the included studies. The main issue was that the study results could not be pooled due to heterogeneity in the definitions of what constitutes a high-volume hospital or surgeon. In addition, there are evolving complexities to factor into surgeon-level analysis, for example, the welcome increase in dual, or sometimes multiple, consultant surgeons operating on the same patient.

The NICE review suggested that there was some evidence for improved outcomes when the threshold for hospital-level volume was set at 10-20 rectal resections per year. However, this evidence was not deemed strong enough to recommend an annual threshold of 20 resections per hospital. Similarly, there was some evidence for improved outcomes when the threshold for surgeon-level volume was set at 5-10 rectal resections per year. As a result, the updated NICE colorectal guidelines now recommend a minimum threshold of 10 cases per year per hospital, and 5 cases per year per surgeon.[9]

In the 2020 National Bowel Cancer Audit (NBOCA) Annual Report, we described rectal surgery volumes at hospital and surgeon level in England and Wales for the first time using NBOCA data.[10] The hospital-level reporting was based on the standard reporting for the audit. This meant that for the purpose of this report, a “hospital” could be an English NHS hospital Trust (which can consist of multiple geographically separate hospital sites), an English NHS hospital site (for English NHS trusts that have requested separate reporting for each site), or a Welsh multidisciplinary team (MDT) (also consisting of multiple geographically separate hospitals). This preliminary work suggested that only 5% of hospitals were performing less than 10 rectal cancer resections. However, 44% of surgeons were performing less than 5 rectal cancer resections per year.

This report aims to expand and improve the methodological work required to capture and present accurate hospital- and surgeon-level volumes as well as to explore whether there are differences between patients, hospitals, and surgeons by volume of surgery. This work will facilitate future explorations of the volume-outcome relationship for rectal cancer surgery, where evidence for the UK is currently insufficient.

Objectives

This report focuses on reporting of rectal cancer surgery volumes in England. This is because the majority of this work involves the development of reporting surgeon-level volumes. Unlike English providers, Welsh providers do not record surgeon-level information in NBOCA. In addition, although Patient Episode Data for Wales (PEDW) has a variable for the capture of responsible consultant General Medical Council (GMC) number, we do not currently have access to this data.

Methodological development

1. To use Hospital Episode Statistics (HES) data to increase the case ascertainment and improve the accuracy of reporting of volumes at hospital and surgeon level
2. To improve the accuracy of reporting of surgeon-level volumes through:
 - a. Validation of surgeon-level information in HES with information in NBOCA
 - b. Novel linkage to GMC data

Hospital and surgeon-level volumes

3. To describe rectal cancer surgery volumes using the updated methodology for:
 - a. English NHS hospital trusts
 - b. Individual hospital sites
 - c. Individual surgeons
4. To describe the patient, clinical, hospital, and surgeon-level characteristics according to volume categories

Methods

Data sources

Patients undergoing a major resection for rectal cancer between 1 April 2015 and 31 March 2019 within the English NHS were identified within HES. Anterior resection, abdomino-perineal excision of the rectum (APER), Hartmann's procedure, pelvic exenteration, and panproctocolectomy were included. Patients recorded as having rectosigmoid tumours were excluded from all analyses due to the heterogeneity of this group.

HES was linked at patient level to NBOCA data to obtain further patient, tumour, and clinical information, and to provide a second source of surgeon GMC code for validation.

Age, sex, performance status, pathological Tumour Nodes Metastases (TNM) staging, American Society of Anaesthesiologists (ASA) grade, surgical access, surgical urgency, and surgical procedure were obtained from NBOCA data.

The Royal College of Surgeons (RCS) Charlson comorbidity score^[11] and socioeconomic status according to the Index of Multiple deprivation^[12] were obtained from HES. The Index of Multiple Deprivation ranks 32,482 geographical areas of England according to their level of deprivation across seven domains. Patients are allocated to an Index of Multiple Deprivation Quintile (IMDQ) based on the national ranking of the area corresponding to their postcode. Ethnicity was obtained from HES and updated with National Cancer Registry data. Due to small numbers of patients with minority-ethnic backgrounds, ethnicity was categorised as "White" and "ethnic minorities (excluding White minorities)".

Radiotherapy information was obtained from linkage to the Radiotherapy Dataset (RTDS). This information included whether or not the patient received pre-operative radiotherapy and, if they did, whether this was long- or short-course radiotherapy.

Comprehensive cancer-centre status was defined as hospitals with both chemotherapy and radiotherapy facilities on-site.

Records were also linked to Association of Coloproctology of Great Britain and Ireland (ACPGBI) data. NBOCA have access to this data for the purposes of Clinical Outcomes Publication (COP) reporting. From this, it was possible to determine whether an individual surgeon had paid membership to this professional association that represents colorectal surgeons. This was used as a proxy for colorectal subspecialisation within General Surgery.

Methodological development

Using HES to increase case ascertainment

The overall case ascertainment for NBOCA for the 2019 audit report was 95% compared to HES.[13] However, this can disproportionately affect certain hospitals, and potentially individual surgeons, dependent on the quality of data submission. In order to improve the accurate capture of rectal cancer surgery volumes, HES data was used to ascertain all volumes. This included also using HES records that did not link to a NBOCA record (unlinked HES) to account for potential data submission issues which may have artificially lowered numbers for some hospital and surgeons, and therefore have the potential to distort any associations between volume and outcome.

Validation of surgeon-level information in HES and NBOCA

Following publication of the Francis report in 2014[14], both NBOCA and HES contain the GMC number of the consultant surgeon responsible for a patient's care, and this was validated by comparing the information between the two datasets. For records where there was a discrepancy between NBOCA and HES, the information recorded in NBOCA was deemed to be the more accurate source of information. This is because data reported to NBOCA is used to report individual surgeon outcomes as part of the Clinical Outcomes Publication (COP), which involves publication of results in the public domain and surgeons are therefore encouraged to carefully check data recorded under their name.

Novel linkage to GMC data

GMC records were available for all registered doctors and these were linked via their GMC number to HES and NBOCA data. This provided additional information about surgeons including speciality (although restricted to General Surgery, not sub-specialities within this), date of entry on the specialist register, revalidation and registration status, and designated body. Revalidation and GMC registration are compulsory for all actively practising doctors in the UK.

The additional GMC information was used as a secondary validation step to ensure that all GMC numbers identified within HES and NBOCA corresponded to a doctor with General Surgery registered as their speciality, because rectal cancer surgery would only be performed by surgeons within this speciality. GMC numbers were restricted to those with a licence to practice and who have ongoing revalidation activity in order to include only active General Surgeons.

In addition, GMC data was used to determine overall surgeon experience by calculating the number of years between the last recorded operation for an individual surgeon and the date they were entered on the specialist register. The median value (10 years) was used as the cut-off to generate a binary variable.

Hospital and surgeon-level volumes

Mean annual rectal cancer surgery volumes were calculated for each English NHS hospital Trust and individual hospital site performing rectal cancer surgery using HES data. All included trusts and hospital sites performed rectal cancer surgery across all years of the included timeframe. Mean annual hospital site volumes were categorised (<10 rectal resections, 10 to 19 rectal resections, 20 to 49 rectal resections, and 50 or more rectal resections) and mapped to explore geographical variation.

Mean annual rectal cancer surgery volumes were calculated for individual surgeons performing rectal cancer surgery using HES data. The mean annual volume was calculated as the number of procedures during the surgeon's active period divided by the duration of the active period. The duration of the active period was defined as the number of years in which the surgeon had procedures recorded and was therefore deemed to be actively operating. The distribution of surgeon volumes was described.

Characteristics according to hospital and surgeon-level volumes

Characteristics were described by tertiles (division in to three equal parts) of both hospital site and surgeon volume. Although overall volumes were determined from HES regardless of linkage to NBOCA, this part of the analysis was restricted to patients with linked NBOCA records as more detailed clinical information is only available within NBOCA. Characteristics were compared across tertiles using chi-squared tests to calculate p values, using 0.05 as the statistical significance level.

Results

Methodological development

Case ascertainment

The preliminary analysis in the 2020 NBOCA Annual Report was performed using the same inclusion criteria as this report. However, the 2020 Annual Report used only NBOCA data to estimate volumes, whereas now we use HES data. This increased the number of patients used to calculate the rectal surgery volumes from 16,059 to 18,747 patients (approximately 15% increase).

Similarly, in the preliminary analysis in the 2020 Annual Report, there were 811 surgeons identified in England, whereas now we identified 856 surgeons according to the linked data used for this report.

Validation of surgeon-level information in HES and NBOCA

Of the 18,747 patients identified as undergoing rectal cancer resection, 15,904 (85%) had surgeon information present in both datasets, 2,799 in HES alone (15%), 36 in NBOCA alone (0.2%), and 8 (<0.1%) had no surgeon information.

Of the 15,904 patients with surgeon information in both datasets, 14,605 (92%) had records with matching GMC numbers in HES and NBOCA. Of the 1,299 patients where the GMC numbers did not match, 13% of GMC numbers within HES corresponded to a different speciality which was most commonly Anaesthetics or Urology. Conversely, 6% of GMC numbers within NBOCA corresponded to

a different specialty which generally corresponded to a different member of the colorectal multidisciplinary team, most commonly Gastroenterology.

Hospital and surgeon-level volumes

Hospital-level volumes

133 English NHS hospital trusts were identified as performing rectal cancer surgery. The median annual volume at this level was 35 rectal cancer resections (interquartile range (IQR) 24 to 52, range 7 to 80).

3 English NHS hospital trusts (2%) had an average annual volume of 5 or less rectal resections. No additional Trusts had an average annual volume of less than 10 rectal resections. 19 English NHS Trusts (14%) had an average annual volume of less than 20 rectal resections.

166 English NHS hospital sites were identified as performing rectal cancer surgery. The median annual volume at this level was 26 rectal cancer resections (interquartile range 19 to 36, range 1 to 74).

3 hospital sites (2%) had an average annual volume of 5 or less rectal resections, 7 hospital sites (4%) had an average annual volume of less than 10 rectal resections, and 44 hospital sites (27%) had an average annual volume of less than 20 rectal resections.

Figure 1 maps the average annual volumes of rectal surgery for each English NHS hospital site. The vast majority of hospital sites with the lowest volumes of rectal cancer resections were found within London. Furthermore, none of the hospital sites with the highest volumes were in London. Similarly, the majority of a cluster of sites in the Manchester/Leeds conurbation had annual volumes less than 20. The 10 highest volume sites were located across a mix of rural regions and urban centres such as Cambridge, Oxford, Portsmouth, and Truro, with none of the highest volume sites in the South-East or the most Northern area of England.

Surgeon-level volumes

856 active Consultant General Surgeons were identified as performing rectal cancer surgery. The median annual volume was 5 rectal cancer resections (IQR 3 to 7, range 1 to 27).

74 surgeons (9%) were recorded as performing an average of 1 rectal resection per year. 380 surgeons (44%) performed an average of less than 5 rectal resections per year, and 765 (89%) less than 10 rectal resections per year.

Of note, there has been an increase in dual consultant surgeon operating, more so following the pandemic where initial guidance advocated this to reduce operating times.[15] Although this may have increased the number of procedures individual surgeons carried out, it is unlikely that this has changed surgeon-level volumes enough to substantially affect our observation that 44% of the consultant surgeons had procedure volumes below the NICE threshold. It is important to note that dual consultant surgeon operating is currently captured neither in NBOCA nor HES, which makes it impossible to study the impact of dual consultant surgeon operating in this report.

Characteristics according to institution-level volumes

13,961 patients with linked HES-NBOCA records were identified. Hospital sites in the lowest tertile performed 1 to 21 rectal resections per year, those in the middle tertile performed 22 to 31 rectal resections per year, and those in the highest tertile performed 32 to 74 rectal resections per year.

Hospital sites in the highest volume tertile were more likely to be comprehensive cancer centres than those in the lowest tertile (58% versus 13%, $p < 0.001$) (Table 1).

In terms of clinical practice, hospital sites in the highest volume tertile were more likely to perform open surgery (27.6% versus 21.7%) and robotic surgery (6.7% versus 2.1%) compared to those in the lowest tertile ($p < 0.001$). Hospital sites in the highest volume tertile also performed slightly more APERs (25.0% versus 23.4%) and pelvic exenterations (1.2% versus 0.1%) than those in the lowest tertile ($p < 0.001$). Hospital sites in the highest tertile performed fewer emergency/urgent procedures with 2.5% compared to 4.2% ($p < 0.001$).

The more frequent use of open surgery in higher volume hospital sites might be partially explained by a higher proportion of complex cases which is supported by a higher proportion of patients having pelvic exenterations. Although there were no statistically significant differences in TNM staging according to hospital volume, there may be differences in other complexities about the surgical procedure, for example, low tumour height or high patient Body Mass Index (BMI). Currently, around one third of data for tumour height is missing and over half for BMI.

Hospital sites in the lowest tertile had higher proportions of ethnic minority groups compared to hospital sites in the highest tertile (7.9% versus 4.1%, $p < 0.001$). They also tended to have higher proportions of more deprived patients (35.5% versus 30.3%, $p < 0.001$). There were statistically significant differences in age, comorbidity, and ASA grade. However, these were small differences and unlikely to be clinically significant. Performance status was difficult to interpret due to larger amounts of missing data in the highest tertile. There was no statistically significant difference in the proportion of patients that were male or female.

Characteristics according to surgeon-level volumes

13,927 patients with linked HES-NBOCA records and surgeon-level information available were identified. Surgeons in the lowest tertile performed 1 to 3 rectal resections per year, those in the middle tertile performed 4 to 6 rectal resections per year, and those in the highest tertile performed 7 or more rectal resections per year.

Surgeons in the lowest tertile were less likely to have ACPGBI membership compared to those in the highest tertile (50.6% versus 65.3%, $p < 0.001$) (Table 2). They also tended to have less experience with 45.3% having at least 10 years practising as a consultant compared to 57.5% in the highest tertile ($p < 0.001$).

Surgeons in the lowest tertile were significantly more likely to perform open procedures (32.4% versus 21.3%) and less likely to perform laparoscopic (66.5% versus 70.4%) and robotic procedures (1.1% versus 8.3%) compared to surgeons in the highest tertile ($p < 0.001$). Surgeons in the lowest tertile were also significantly more likely to perform emergency/urgent procedures (6.0% versus 2.6%, $p < 0.001$). With respect to the type of surgical procedure, surgeons in the lowest tertile were more likely to perform Hartmann's procedures (13.1% versus 8.5%) rather than anterior resections

(61.3% versus 64.1%) or APERs (23.0% versus 25.1%), compared to surgeons in the highest tertile ($p < 0.001$).

Surgeons in the lowest tertile were more likely to treat deprived patients compared to surgeons in the highest tertile (16.4% versus 13.9% in the most deprived quintile, $p < 0.001$). Surgeons in the lowest tertile, were also more likely to treat ethnic minority patients (7.5% versus 4.3%, $p < 0.001$). There were statistically significant differences for sex, performance status, and metastatic disease. However, these differences were small and they were unlikely to be clinically significant. There were no statistically significant differences in age, comorbidity, pathological T- and N-stage, or ASA grade.

Limitations & Further Work

This report has highlighted some limitations and further areas for exploration:

- We do not currently have access to surgeon-level information for Wales.
- Surgeon-level volumes reported may be slightly underestimated as NBOCA currently only allows the recording of one consultant surgeon.
- When considering case-mix differences, it is likely that there will be residual confounding, originating from complexities of rectal surgery which are currently not very well captured (e.g., tumour height, patient BMI).
- Additional important work informed by this report to be carried out to assess the impact of hospital and surgeon-level volumes on surgical outcomes to address gaps in knowledge. For example, this report highlighted the importance of adequate adjustment for case-mix and clinical differences. This further work will also include investigating the distribution of surgeon-level volumes by hospital-level volumes.

Summary and Conclusions

This report demonstrates that:

- Case ascertainment is increased and more accurately determined by using HES to capture hospital and surgeon-level volumes.
- Surgeon-level information captured from HES shows good agreement to that captured in NBOCA, and the novel linkage to GMC data further improves the accuracy of surgeon-level reporting by highlighting GMC numbers corresponding to specialities other than General Surgery.
- Large numbers of hospital sites are performing rectal cancer surgery, with considerable variation in the numbers of procedures being performed (1 to 74 rectal cancer resections per year), and little evidence of specialisation. In particular, there are a large number of lower volume hospitals in London with any specialisation of services here unlikely to impact travel times.
- Although most English NHS hospital sites are performing more than 10 rectal resections per year according to NICE guidelines, there are a handful of hospital sites that do not meet this threshold.
- A significant proportion of surgeons (44%) are currently not performing the minimum number of 5 rectal resections per year recommended in NICE guidelines.

- Clear differences exist in the characteristics and clinical practice of low and high-volume hospitals, with high-volume hospitals more likely to be a comprehensive cancer centre and to perform open and robotic surgery. Smaller case-mix differences exist, with low-volume sites more likely to treat patients from deprived areas or from ethnic minorities.
- Clear differences also exist in the characteristics and clinical practice of low and high-volume surgeons, with high-volume surgeons more likely to perform laparoscopic and robotic surgery, as well as a higher proportion of anterior resections and APERs. Low-volume surgeons perform a larger proportion of Hartmann's procedures. High-volume surgeons are also more likely to be ACPGBI members and have more overall experience as consultants. Case-mix differences are less apparent between low and high volume surgeons.

Figure 1 – Map demonstrating average annual rectal surgery volumes per English NHS hospital site

Number of rectal surgery procedures per site

Figure 1 – Map demonstrating average annual rectal surgery volumes per English NHS hospital site

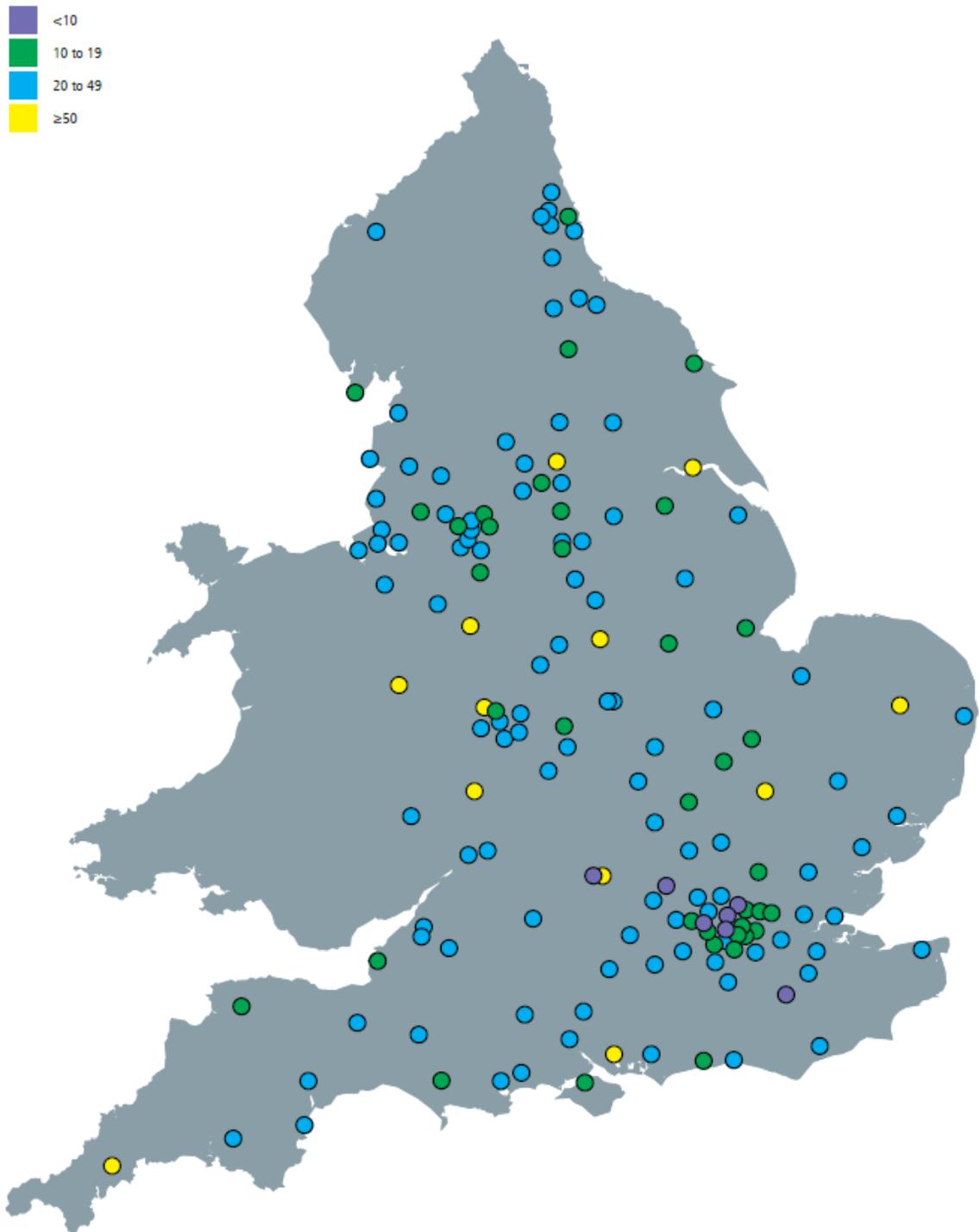


Table 1 – Patient, clinical, and hospital-level characteristics according to tertiles of mean annual volume of rectal cancer resections at hospital site level

	Site Volume (Tertiles*)			P value (χ^2)
	Lowest (n=2,718) 60 sites No. (%)	Medium (n=4,116) 51 sites No. (%)	Highest (n=7,127) 55 sites No. (%)	
Age				0.011
<50	226 (8.3)	273 (6.6)	520 (7.3)	
50-59	514 (18.9)	734 (17.8)	1,269 (17.8)	
60-74	1,263 (46.5)	2,119 (51.5)	3,550 (49.8)	
75-84	627 (23.1)	872 (21.2)	1,579 (22.2)	
≥85	88 (3.2)	118 (2.9)	209 (2.9)	
Sex				0.497
Male	1,797 (66.1)	2,673 (64.9)	4,625 (64.9)	
Female	921 (33.9)	1,443 (35.1)	2,502 (35.1)	
RCS** Charlson Score				0.003
0	1,549 (57.0)	2,389 (58.0)	4,265 (59.8)	
1	838 (30.8)	1,154 (28.0)	1,959 (27.5)	
≥2	331 (12.2)	573 (13.9)	903 (12.7)	
Performance Status				<0.001
0	1,565 (60.8)	2,393 (65.2)	3,897 (64.9)	
1	733 (28.5)	1,035 (28.2)	1,610 (26.8)	
≥2	277 (10.8)	241 (6.6)	500 (8.3)	
Missing	143 (5.3)	447 (10.9)	1,120 (15.7)	
Pathological Tumour stage				0.225
T1	320 (12.7)	470 (12.3)	916 (13.9)	
T2	722 (28.6)	1,147 (29.9)	1,877 (28.5)	
T3	1,283 (50.8)	1,926 (50.3)	3,280 (49.9)	
T4	200 (7.9)	287 (7.5)	504 (7.7)	
Missing	193 (7.1)	286 (6.9)	550 (7.7)	
Pathological Nodes Stage				0.219
N0	1,602 (63.8)	2,439 (63.6)	4,188 (63.7)	
N1	659 (26.2)	948 (24.7)	1,648 (25.1)	
N2	251 (10.0)	450 (11.7)	741 (11.3)	
Missing	206 (7.6)	279 (6.8)	550 (7.7)	
Pathological Metastases Stage				0.192
M0	2,357 (95.5)	3,646 (96.4)	6,069 (96.1)	
M1	111 (4.5)	136 (3.6)	244 (3.9)	
Missing	250 (9.2)	334 (8.1)	814 (11.4)	
ASA*** Grade				0.035
1	412 (15.8)	604 (15.5)	1,008 (14.9)	
2	1,532 (58.9)	2,435 (62.3)	4,152 (61.3)	
≥3	656 (25.2)	870 (22.3)	1,614 (23.8)	
Missing	118 (4.3)	207 (5.0)	353 (5.0)	

Pre-operative radiotherapy				0.012
No radiotherapy	1,760 (64.8)	2,708 (65.8)	4,783 (67.1)	
Long Course	714 (26.3)	1,090 (26.5)	1,848 (25.9)	
Short Course	244 (9.0)	318 (7.7)	496 (7.0)	
IMDQ[†]				<0.001
1 (most deprived)	418 (15.4)	706 (17.2)	982 (13.8)	
2	545 (20.1)	739 (18.0)	1,175 (16.5)	
3	603 (22.2)	863 (21.0)	1,510 (21.2)	
4	606 (22.3)	928 (22.6)	1,636 (23.0)	
5 (least deprived)	542 (20.0)	869 (21.2)	1,812 (25.5)	
Missing	4 (0.1)	11 (0.3)	12 (0.2)	
Ethnicity^{††}				<0.001
White	2,401 (92.1)	3,754 (95.8)	6,452 (95.9)	
Ethnic minorities (excluding White minorities)	205 (7.9)	163 (4.2)	278 (4.1)	
Missing	112 (4.1)	199 (4.8)	397 (5.6)	
Surgical access				<0.001
Open	587 (21.7)	1,067 (26.0)	1,958 (27.6)	
Laparoscopic	2,062 (76.2)	2,799 (68.2)	4,670 (65.7)	
Robotic	56 (2.1)	238 (5.8)	477 (6.7)	
Missing	13 (0.5)	12 (0.3)	22 (0.3)	
Surgical Urgency				<0.001
Elective/Scheduled	2,597 (95.8)	3,901 (95.3)	6,928 (97.5)	
Emergency/Urgent	115 (4.2)	192 (4.7)	175 (2.5)	
Missing	6 (0.2)	23 (0.6)	24 (0.3)	
Surgical Procedure				<0.001
Anterior resection	1,762 (64.8)	2,577 (62.6)	4,489 (63.0)	
Abdomino-perineal excision of the rectum	636 (23.4)	1,052 (25.6)	1,783 (25.0)	
Hartmann's	285 (10.5)	412 (10.0)	666 (9.3)	
Pelvic Exenteration	4 (0.1)	22 (0.5)	88 (1.2)	
Panproctocolectomy	31 (1.1)	53 (1.3)	101 (1.4)	
Comprehensive cancer centre				<0.001
No	2,364 (87.0)	3,087 (75.0)	2,964 (41.6)	
Yes	354 (13.0)	1,029 (25.0)	4,163 (58.4)	

*Tertile - division in to three equal parts

**Royal College of Surgeons Charlson comorbidity score

***American Society of Anaesthesiologists

† Index of Multiple Deprivation Quintile

†† Ethnicity reported as per [guidance](#)

Table 2 – Patient, clinical, and surgeon-level characteristics according to tertiles of mean annual volume of rectal cancer resections at surgeon level

	Surgeon Volume (Tertiles*)			P value
	Lowest (n=1,500) 270 surgeons	Medium (n=4,553) 318 surgeons	Highest (n=7,874) 268 surgeons	
	No. (%)	No. (%)	No. (%)	
Age				0.186
<50	105 (7.0)	344 (7.6)	567 (7.2)	
50-59	251 (16.7)	820 (18.0)	1,442 (18.3)	
60-74	791 (52.7)	2,242 (49.2)	3,883 (49.3)	
75-84	300 (20.0)	1,022 (22.4)	1,747 (22.2)	
≥85	53 (3.5)	235 (2.7)	235 (3.0)	
Sex				0.018
Male	1,003 (66.9)	2,894 (63.6)	5,174 (65.7)	
Female	497 (33.1)	1,659 (36.4)	2,700 (34.3)	
RCS** Charlson Score				0.250
0	850 (56.7)	2,651 (58.2)	4,686 (59.5)	
1	440 (29.3)	1,308 (29.3)	2,190 (27.8)	
≥2	210 (14.0)	594 (13.0)	998 (12.7)	
Performance Status				0.029
0	859 (63.3)	2,552 (62.6)	4,433 (65.3)	
1	371 (27.3)	1,170 (28.7)	1,827 (26.9)	
≥2	127 (9.4)	355 (8.7)	529 (7.8)	
Missing	143 (9.5)	476 (10.5)	1,085 (13.8)	
Pathological Tumour stage				0.058
T1	153 (11.1)	541 (12.8)	1,010 (13.9)	
T2	415 (30.0)	1,243 (29.4)	2,083 (28.6)	
T3	694 (50.1)	2,130 (50.3)	3,655 (50.2)	
T4	122 (8.8)	319 (7.5)	536 (7.4)	
Missing	116 (7.7)	320 (7.0)	590 (7.5)	
Pathological Nodes Stage				0.636
N0	880 (63.6)	2,704 (64.0)	4,631 (63.6)	
N1	363 (26.2)	1,056 (25.0)	1,824 (25.0)	
N2	140 (10.1)	467 (11.0)	830 (11.4)	
Missing	117 (7.8)	326 (7.2)	589 (7.5)	
Pathological Metastases Stage				0.002
M0	1,276 (94.8)	3,977 (95.7)	6,796 (96.6)	
M1	70 (5.2)	178 (4.3)	239 (3.4)	
Missing	154 (10.3)	398 (8.7)	839 (10.7)	
ASA*** Grade				0.263
1	216 (15.2)	706 (16.2)	1,099 (14.7)	
2	864 (60.6)	2,642 (60.7)	4,597 (61.5)	
≥3	345 (24.2)	1,006 (23.1)	1,775 (23.8)	
Missing	75 (5.0)	199 (4.4)	403 (5.1)	

Pre-operative radiotherapy				<0.001
No radiotherapy	1,011 (67.4)	2,939 (64.6)	5,273 (67.0)	
Long Course	357 (23.8)	1,227 (26.9)	2,065 (26.2)	
Short Course	132 (8.8)	387 (8.5)	536 (6.8)	
IMDQ[†]				<0.001
1 (most deprived)	246 (16.4)	762 (16.8)	1,090 (13.9)	
2	275 (18.3)	822 (18.1)	1,353 (17.2)	
3	323 (21.5)	956 (21.1)	1,696 (21.6)	
4	354 (23.6)	978 (21.5)	1,830 (23.3)	
5 (least deprived)	301 (20.1)	1,023 (22.5)	1,891 (24.1)	
<i>Missing</i>	1 (0.1)	12 (0.3)	14 (0.2)	
Ethnicity^{††}				<0.001
White	1,333 (92.5)	4,127 (94.9)	7,114 (95.7)	
Ethnic minorities (excluding White minorities)	108 (7.5)	220 (5.1)	318 (4.3)	
<i>Missing</i>	59 (3.9)	206 (4.5)	442 (5.6)	
Surgical access				<0.001
Open	485 (32.4)	1,430 (31.5)	1,671 (21.3)	
Laparoscopic	994 (66.5)	3,006 (66.2)	5,524 (70.4)	
Robotic	16 (1.1)	103 (2.3)	652 (8.3)	
<i>Missing</i>	5 (0.3)	14 (0.3)	27 (0.3)	
Surgical Urgency				<0.001
Elective/Scheduled	1,408 (94.0)	4,362 (96.3)	7,642 (97.4)	
Emergency/Urgent	90 (6.0)	168 (3.7)	204 (2.6)	
<i>Missing</i>	2 (0.1)	23 (0.5)	28 (0.4)	
Surgical Procedure				<0.001
Anterior resection	919 (61.3)	2,848 (62.6)	5,049 (64.1)	
Abdomino-perineal excision of the rectum	345 (23.0)	1,143 (25.1)	1,977 (25.1)	
Hartmann's	197 (13.1)	487 (10.7)	666 (8.5)	
Pelvic Exenteration	14 (0.9)	9 (0.2)	91 (1.2)	
Panproctocolectomy	25 (1.7)	66 (1.4)	91 (1.2)	
ACPGBI[‡] Membership				<0.001
No	741 (49.4)	2,025 (44.5)	2,731 (34.7)	
Yes	759 (50.6)	2,528 (55.5)	5,143 (65.3)	
Overall consultant experience				<0.001
<10 years	790 (54.7)	2,069 (45.9)	3,330 (42.5)	
≥10 years	654 (45.3)	2,440 (54.1)	4,507 (57.5)	
<i>Missing</i>	56 (3.7)	44 (1.0)	37 (0.5)	

*Tertile - division in to three equal parts

**Royal College of Surgeons Charlson comorbidity score

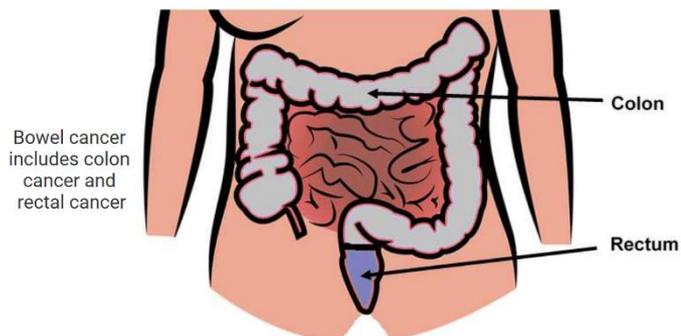
***American Society of Anaesthesiologists

† Index of Multiple Deprivation Quintile

†† Ethnicity reported as per [guidance](#)

‡ Association of Coloproctology of Great Britain and Ireland

Glossary



Abdomino-perineal excision of the rectum (APER) - operation to remove the entire rectum and anal canal. The patient is left with a permanent stoma.

Association of Coloproctology of Great Britain and Ireland (ACPGBI) – a group of colorectal surgeons, nurses and allied health professionals who advance the knowledge and

treatment of bowel diseases in Britain and Ireland.

Adjuvant therapy – these are treatments given to a patient *after* they have surgery and might consist of chemotherapy and/or radiotherapy.

Anterior resection - operation to remove part, or all, of the rectum.

American Society of Anaesthesiologists (ASA) – a system for assessing how fit somebody is before they have surgery, with a value of 1 representing the most fit.

Body Mass Index (BMI) – a measure that uses height and weight to determine if a person's weight is healthy.

Chemotherapy - drug therapy used to treat cancer. It may be used alone, or in combination with other types of treatment (for example surgery or radiotherapy).

General Medical Council (GMC) – a public body which regulates doctors within the United Kingdom.

Hartmann's procedure - operation to remove an area of the bowel on the left hand side of the abdomen and top end of the rectum. It involves the formation of a stoma, but this is not necessarily permanent.

Hospital Episode Statistics (HES) – a database containing details of all hospital admissions in NHS hospitals in England.

Index of Multiple Deprivation Quintile (IMDQ) - the Index of Multiple Deprivation ranks 32,482 geographical areas of England according to their level of deprivation across seven domains. People can then be allocated to an Index of Multiple Deprivation Quintile (IMDQ) based on the national ranking of the area corresponding to their postcode.

Laparoscopic – also known as minimally invasive surgery or keyhole surgery. This is a type of surgical procedure performed through small cuts in the skin instead of the larger cuts used in open surgery.

Local excision - procedure done with instruments inserted through the anus (often during a colonoscopy), without cutting into the skin of the abdomen to remove just a small piece of the lining of the colon or rectum wall.

Metastases - cancer that has spread from where it first started in the body. These can also be called secondary cancers.

Neo-adjuvant therapy – these are treatments given to a patient *before* they have surgery and might consist of chemotherapy and/or radiotherapy.

Open surgery - operation carried out by cutting an opening in the abdomen.

Panproctocolectomy – operation involving the removal of the colon and rectum, often leaving a permanent stoma (opening of the bowel through the abdomen to allow poo to pass out into a bag).

Patient Episode Database Wales (PEDW) – a database containing details of all hospital admissions in NHS hospitals in Wales.

Pelvic exenteration – operation involving the removal of multiple organs of the pelvis along with bowel. For example, it may include the removal of the bladder or vagina/uterus.

Radiotherapy - the treatment of disease, especially cancer, using x-rays or similar forms of radiation.

Rectal cancer – ‘bowel cancer’ involving the final part of the large bowel, also known as the rectum (see diagram above).

Robotic surgery – this is a relatively new advancement in surgery and allows surgeons to control surgical instruments whilst sitting at a special console away from the patient during the operation.

Royal College of Surgeons (RCS) Charlson score – a system for quantifying how many specific underlying medical conditions a person has before they have an operation, for example, previous heart conditions or diabetes.

Tertile - division in to three equal parts.

Tumour Nodes Metastases (TNM) staging – a system to describe the amount and spread of cancer in the body. The ‘T’ refers to ‘Tumour’ and describes the main tumour. The ‘N’ refers to ‘Nodes’ and describes how many lymph nodes or ‘glands’ have cancer. The ‘M’ refers to ‘Metastases’ and describes cancer that has spread to other parts of the body.

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