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ORIGINAL ARTICLE

The impact of surgical specialisation on survival following elective colon cancer surgery

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Abstract
Purpose Reorganisation of cancer services in the UK and across Europe has led to elective surgery for colon cancer being increasingly, but not exclusively, delivered by specialist colorectal surgeons. This study examines survival after elective colon cancer surgery performed by specialist compared to non-specialist surgeons.
Method Patients undergoing elective surgery for colon cancer in 16 hospitals between 2001 and 2004 were identified from a prospectively maintained regional audit database. Post-operative mortality (<30 days) and 5-year relative survival in those receiving surgery under the care of a specialist or non-specialist surgeon were compared.
Results A total of 1,856 patients were included, of which, 1,367 (73.7 %) were treated by a specialist and 489 (26.4 %) by a non-specialist surgeon. Those treated by a specialist were more likely to be deprived, undergo surgery in a high volume unit and have higher lymph node yields than those treated by a non-specialist. Post-operative mortality was lower (4.5 versus 7.0 %; $P=0.032$) and 5-year relative survival was higher (72.2 versus 65.6 %; $P=0.012$) among those treated by a specialist surgeon. In multivariate analysis, surgery by non-specialists was independently associated with increased post-operative mortality (adjusted odds ratio (OR) 1.69; $P<0.001$) and poorer 5-year relative survival (adjusted relative excess risk (RER) 1.17; $P=0.045$). After exclusion of post-operative deaths, there was no difference in long-term survival (adjusted RER 1.08; $P=0.505$).
Conclusion Five-year relative survival after elective colon cancer surgery was higher among those treated by specialist colorectal surgeons due to increased post-operative mortality among those treated by non-specialists.

Keywords Colon cancer · Specialisation · Relative survival · Post-operative mortality · Elective surgery

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Introduction

Surgery for colon cancer has traditionally been performed by both general surgeons and colorectal specialists in most acute hospitals. Reorganisation of cancer services in the UK and across Europe over recent decades has led to surgery for colon cancer being increasingly, but not exclusively, delivered by specialist surgeons. The subsequent rise in specialisation over this period has significantly contributed to overall improvements in long-term survival from colorectal cancer [1].Current management guidelines for colorectal cancer recommend that surgery should only be performed by appropriately trained surgeons, especially rectal cancer surgery, but there is little detail regarding the level of specialisation required [2].

A recently published Cochrane Collaboration systematic review [3] concluded that surgical specialisation, in addition to hospital and surgeon volume, were associated with improved outcomes following colorectal cancer surgery. However, the quality of evidence available was low and little research was available that specifically examined the relationship between surgical specialisation and outcomes following elective colon cancer surgery. This was due to many previous

studies presenting combined outcomes for both colon and rectal cancer surgery together despite differences in clinicopathological characteristics, management strategies and modes of presentation between tumour sites [4, 5]. In addition, there is considerable variation in the definition of a specialist surgeon with previous studies using board certification [6, 7], time served as a specialist [8], self-declared sub-speciality interest [4, 9], membership of a specialist association [5, 10] or peer assessment [11]. Therefore, while there is some evidence that specialisation in any form leads to improved outcomes for colorectal cancer, less is known about its relationship with colon cancer. It remains unclear as to the influence of such health care provider characteristics on outcomes after elective surgery for colon cancer to enable adequate health care service planning and provision.

Therefore, the aim of this study was to explore the influence of specialty of surgeon on both post-operative mortality and 5-year relative survival after elective surgery for colon cancer using a robust definition of a specialist colorectal surgeon.

Methods

Clinical audit data of patients undergoing planned elective surgery for colon cancer in 16 hospital sites from 1 January 2001 to 31 December 2004 were extracted from the prospectively maintained database of the West of Scotland Colorectal Cancer Managed Clinical Network. Individual patient records were then linked to the Scottish Cancer Registry (SMR6). Details included age, sex, deprivation category, site and pathological details of resected tumour, intent of surgery, specialty of surgeon (colorectal specialist or non-specialist), hospital of surgery and anastomotic leak rate.

Colon cancers (C18) were classified according to their anatomical site as per the International Classification of Disease version 10 (ICD-10). Lesions of caecum, ascending colon and hepatic flexure were classified as right colonic tumours. Those of the transverse colon, splenic flexure and descending colon were classified as left colonic tumours. Cancers arising from the sigmoid were classified separately. Tumours of the appendix (C18.1) were excluded.

Tumour stage was based on histological examination of the resected specimen and radiology reports using the American Joint Committee on Cancer (AJCC) staging classification. Patients were deemed to have had a curative resection if the surgeon considered that there was no macroscopic residual tumour and verified histologically as a complete resection (R0). Surgery was deemed palliative if there was incomplete (R1, R2) or unresectable disease at time of surgery, or as identified preoperatively from staging investigation.

Individual surgeons were identified as colorectal specialists (colorectal surgeons) or non-specialists (general surgeons) by panel members of the corresponding colorectal cancer multidisciplinary team (MDT) of the hospitals under study, as previously described [12]. A specialist colorectal surgeon was defined as one who fulfilled each of the following criteria: (i) had a major commitment to colorectal cancer surgery with in the UK National Health Service (NHS), (ii) were regarded as a colorectal surgeon by their peers and colleagues, (iii) regularly performed diagnostic and interventional colonoscopy and (iv) were an active member of a local colorectal cancer MDT. All other surgeons were classified as non-specialists. Hospital volume (high versus low) was determined depending on whether individual units performed more or less than the mean number of elective colonic resections of all units.

Socioeconomic circumstances were measured using the area-based Scottish Index of Multiple Deprivation (SIMD) 2006 [13]. SIMD scores are presented in five groups with 1 representing the least deprived and 5 the most deprived.

Patient records were linked to the General Registry Office for Scotland (GROS) death records. Minimum follow-up of survivors was 5 years. Post-operative mortality was defined as any death occurring within 30 days of surgery. Relative survival is expressed as the ratio of the overall survival of study participants and the survival that would be expected when exposed only to the background mortality adjusting for age, sex and deprivation category. Annual age, sex and SIMD-specific Scottish life-tables produced by the London School of Hygiene and Tropical Medicine were used to estimate background population mortality.

Statistical methods

Comparisons of the association between baseline clinicopathological characteristics, treatment variables and speciality of surgeon were made using the χ^2 test and Student's t test where appropriate. Survival time was calculated from date of surgery to the date of death or censor with a minimum of 5-year follow-up (date of censor 31 December 2010). Patients were excluded from the relative survival analysis if no follow-up time was calculable (i.e. patient died on day of surgery). Factors associated with post-operative mortality were identified using univariate and multivariate logistic regression models. Relative survival was used to estimate 5-year survival. The Hakulinen-Tenkanen approach to model excess mortality was used for the multivariate relative survival analysis. Relative excess risk (RER) and odds ratios (ORs) are presented with 95 % confidence intervals (95 % CI), and $P<0.050$ was considered statistically significant. Analysis was performed using STATA® software package version 11(IC) (Stata Corp. LP, College Station, TX, USA).

Ethical approval

The West of Scotland Cancer Surveillance Unit obtained permission to obtain cancer registry data both from Caldicott

Guardians of all health boards in the West of Scotland and from the Information Services Division of the NHS in Scotland Privacy Advisory Committee. Permission to use clinical audit data as a review of service provision was granted by the West of Scotland Colorectal Cancer Managed Clinical Network advisory board. As this study was a retrospective review of clinical practice, no formal ethical approval was required.

Results

A total of 1,856 (50.5 % male) patients who underwent surgery for colon cancer from 1 January 2001 to 31 December 2004 were included. The mean age was 70.6 years (standard deviation (s.d.) 10.7; range 24.4–96.2 years). The mean follow-up period was 5.0 years (s.d. 3.3; range 0–10.1 years). The mean number of elective procedures for colon cancer performed per annum in each hospital unit was 29. Eight hospitals were classified as low volume (<29 per annum) and eight as high volume (≥29 per annum).

Univariate associations between baseline clinicopathological characteristics and speciality of surgeon are shown in Table 1. In total, 113 surgeons contributed cases, of which, 40 were identified as specialists and 73 were non-specialists. Almost three quarters of patients received surgery under the care of a specialist surgeon. Patients receiving surgery under the care of a specialist surgeon were more likely to be deprived and undergo surgery in a high volume unit than those treated by a non-specialist. Those who underwent surgery with curative intent had a higher lymph node yield when surgery was performed by a specialist compared to a non-specialist surgeon. On average, specialist surgeons performed almost three times as many elective operations for colon cancer per annum than non-specialist surgeons.

Post-operative mortality

Overall, 95 patients (5.1 %) died within 30 days of surgery. Univariate and multivariate analysis of factors associated with post-operative mortality are shown in Table 2. Overall post-operative mortality was higher among those treated by a non-specialist compared to a specialist surgeon (7.0 versus 4.5 %, respectively (P=0.032)). After adjustment, those treated by a non-specialist had a 69.0 % increased risk of dying within the first 30 days of surgery (adjusted OR 1.69 (95 % CI 1.07–2.68); P=0.026) compared to patients receiving surgery under the care of a specialist surgeon. Advancing age, left colon tumours, presence of vascular invasion, non-resectional palliative surgery and anastomotic leakage were also independently associated with increased post-operative mortality. Hospital case volume was not associated with post-operative mortality.

Table 1 Comparison of clinicopathological characteristics by speciality of surgeon

	Specialist surgeon (n=1,367)	Non-specialist surgeon (n=489)	P value[a]
Age in years at surgery			
Mean (s.d.)	70.6 (10.6)	70.6 (11.0)	0.932[b]
Gender			0.117
Male	705 (51.6)	232 (47.4)	
Female	662 (48.4)	257 (52.6)	
Socioeconomic group			0.001
1 (Most affluent)	219 (16.0)	84 (17.2)	
2	174 (12.6)	79 (16.2)	
3	225 (16.5)	103 (21.1)	
4	338 (24.7)	119 (24.3)	
5 (Most deprived)	413 (30.2)	104 (21.3)	
Tumour stage			0.087
I	208 (15.2)	61 (12.5)	
II	502 (36.7)	189 (38.7)	
III	396 (29.0)	133 (27.2)	
IV	238 (17.4)	89 (18.2)	
Unknown[c]	23 (1.7)	17 (3.5)	
Site of tumour			0.016
Right colon	560 (41.0)	236 (48.3)	
Left colon	234 (17.1)	79 (16.2)	
Sigmoid	573 (41.9)	174 (35.6)	
Degree of differentiation			0.220
Well/Moderate	1118 (81.8)	369 (75.5)	
Poor	173 (12.7)	69 (14.1)	
Unknown[c]	76 (5.6)	51 (10.4)	
Vascular invasion			0.604
No	918 (67.2)	305 (62.4)	
Yes	301 (22.0)	107 (21.9)	
Unknown[c]	148 (10.8)	77 (15.8)	
Lymph nodes examined[d]			0.013[b]
Mean (s.d.)	12.2 (6.9)	11.3 (6.7)	
Intent of surgery			0.140
Curative resection	1106 (80.9)	376 (76.9)	
Palliative resection	225 (16.5)	95 (19.4)	
Surgery, no resection	36 (2.6)	18 (3.7)	
Anastomotic leak[e]	28 (2.2)	7 (1.6)	0.422
Surgeon case volume (per annum)			
Mean (s.d.)	15.8 (6.7)	5.5 (3.6)	<0.001
Hospital volume			<0.001
Low	439 (32.1)	204 (41.7)	
High	928 (67.9)	285 (58.3)	

Values in parentheses are percentages unless otherwise indicated

[a] χ^2 for trend unless otherwise indicated

[b] Student's t test

[c] Numbers unknown excluded from comparison

[d] In those undergoing curative resection only

[e] Of anastomoses created

Table 2 Univariate and multivariate analyses of factors associated with post-operative mortality

	Number of post-operative deaths (%)	Unadjusted *P* value	Multivariate analysis Odds ratio (95 % CI)	Adjusted *P* value
Age at diagnosis		<0.001		
<65	7 (1.4)		1.00	0.008
65–74	23 (3.5)		3.33 (1.37, 8.10)	<0.001
≥75	65 (9.3)		10.73 (4.65, 24.74)	
Gender		0.203		
Male	54 (5.8)			
Female	41 (4.5)			
Socioeconomic group		0.585		
1 (Most affluent)	11 (3.6)			
2	12 (4.8)			
3	18 (5.5)			
4	22 (4.8)			
5 (Most deprived)	32 (6.2)			
Tumour stage		0.001		
I	11 (4.1)		1.00	0.370
II	26 (3.8)		0.71 (0.33, 1.50)	0.373
III	24 (4.5)		0.70 (0.31, 1.54)	0.370
IV	32 (9.8)		1.57 (0.59, 4.18)	0.855
Unknown	2 (5.0)		0.85 (0.14, 5.00)	
Site of tumour		0.341		
Right colon	34 (4.3)		1.00	0.036
Left colon	19 (6.1)		1.75 (1.04, 2.95)	0.203
Sigmoid	42 (5.6)		0.53 (0.20, 1.41)	
Degree of differentiation		0.225		
Well/Moderate	71 (4.8)			
Poor	16 (6.6)			
Unknown	8 (6.3)			
Vascular invasion		0.006		
No	51 (4.2)		1.00	0.036
Yes	31 (7.6)		1.75 (1.04, 2.95)	0.203
Unknown	13 (5.8)		0.53 (0.20, 1.41)	
Intent of surgery		<0.001		
Curative resection	61 (4.1)		1.00	0.383
Palliative resection	24 (7.5)		1.40 (0.66, 2.97)	0.002
Surgery, no resection	10 (18.5)		7.34 (2.13, 25.25)	
Anastomotic leak		<0.001		
No	85 (4.7)		1.00	<0.001
Yes	10 (28.6)		16.85 (7.04, 40.35)	
Specialty of surgeon		0.032		
Specialist	61 (4.5)		1.00	0.026
Non-specialist	34 (7.0)		1.69 (1.07, 2.68)	
Hospital volume		0.260		
Low	38 (5.9)			
High	57 (4.7)			

Five-year relative survival

At 5 years following surgery, 842 patients (45.4 %) had died. One patient died on the day of surgery (specialist surgeon group) and was excluded from the relative survival analysis. The overall 5-year relative survival rate was 70.4 % (95 % CI 67.5–73.3). Univariate and multivariate analysis of factors associated with 5-year relative survival are shown in Table 3.

Table 3 Univariate and multivariate analyses of factors associated with 5-year relative survival

	Five-year relative survival rate	Unadjusted *P* value	Multivariate analysis RER	Adjusted *P* value
Age at diagnosis		0.223		
<65	68.7 (64.0, 73.0)			
65–74	73.5 (68.9, 77.9)			
≥75	69.3 (63.2, 75.4)			
Gender		0.953		
Male	70.3 (66.0, 74.4)			
Female	70.6 (66.5, 74.5)			
Socioeconomic group		0.125		
1 (Most affluent)	78.3 (71.5, 84.4)			
2	66.7 (58.9, 74.0)			
3	69.9, 62.7, 76.6)			
4	65.3 (59.2, 71.1)			
5 (Most deprived)	72.6 (66.6, 78.3)			
Tumour stage		<0.001		
I	99.7 (92.6, 105.6)		1.00	0.130
II	87.2 (82.5, 91.6)		2.05 (0.81, 5.20)	0.003
III	69.3 (63.7, 74.5)		3.96 (1.59, 9.86)	<0.001
IV	15.6 (11.5, 20.4)		8.70 (3.42, 22.11)	0.006
Unknown	56.1 (35.8, 75.3)		4.29 (1.51, 12.22)	
Site of tumour		0.003		
Right colon	67.3 (62.7, 71.8)		1.00	0.740
Left colon	64.2 (56.8, 71.2)		0.96 (0.73, 1.25)	0.034
Sigmoid	76.3 (71.7, 80.6)		0.78 (0.62, 0.98)	
Degree of differentiation		<0.001		
Well/Moderate	73.4 (70.1, 76.6)		1.00	<0.001
Poor	57.6 (49.4, 65.5)		1.62 (1.25, 2.10)	0.547
Unknown	60.3 (49.2, 70.5)		1.13 (0.75, 1.71)	
Vascular invasion		<0.001		
No	80.6 (77.0, 84.1)		1.00	<0.001
Yes	47.3 (41.4, 53.2)		1.75 (1.40, 2.19)	0.024
Unknown	57.4 (48.9, 65.6)		1.55 (1.06, 2.27)	
Intent of surgery		<0.001		
Curative resection	83.6 (80.4, 86.7)		1.00	<0.001
Palliative resection	20.6 (15.8, 26.0)		2.82 (2.09, 3.81)	<0.001
Surgery, no resection	7.2 (1.9, 18.0)		6.33 (3.93, 10.21)	
Anastomotic leak		0.002		
No	70.1 (67.8, 73.7)		1.00	<0.001
Yes	51.6 (31.8, 70.3)		3.95 (2.16, 7.23)	
Specialty of surgeon		0.012		
Specialist	72.2 (68.7, 75.5)		1.00	0.045
Non-specialist	65.6 (59.8, 71.2)		1.17 (1.01, 1.33)	
Hospital volume		0.150		
Low	67.8 (62.9, 72.6)			
High	71.8 (68.1, 75.4)			

Values in parentheses are 95 % CIs

RER relative excess risk

Five-year relative survival rates were higher among those receiving surgery under the care of a specialist compared to a non-specialist surgeon (72.2 % (95 % CI 68.7–75.5) versus 65.6 % (95 % CI 59.8–71.2); $P=0.012$) (Fig. 1). After adjustment, those treated by a non-specialist had a 17.0 % increased risk of dying from their cancer compared to those treated by a specialist (adjusted RER 1.17 (95 % CI 1.01–1.33); $P=0.045$). Advancing tumour stage, poor tumour differentiation, presence of vascular invasion, non-curative surgery, anastomotic leakage and non-sigmoid colon tumours were also

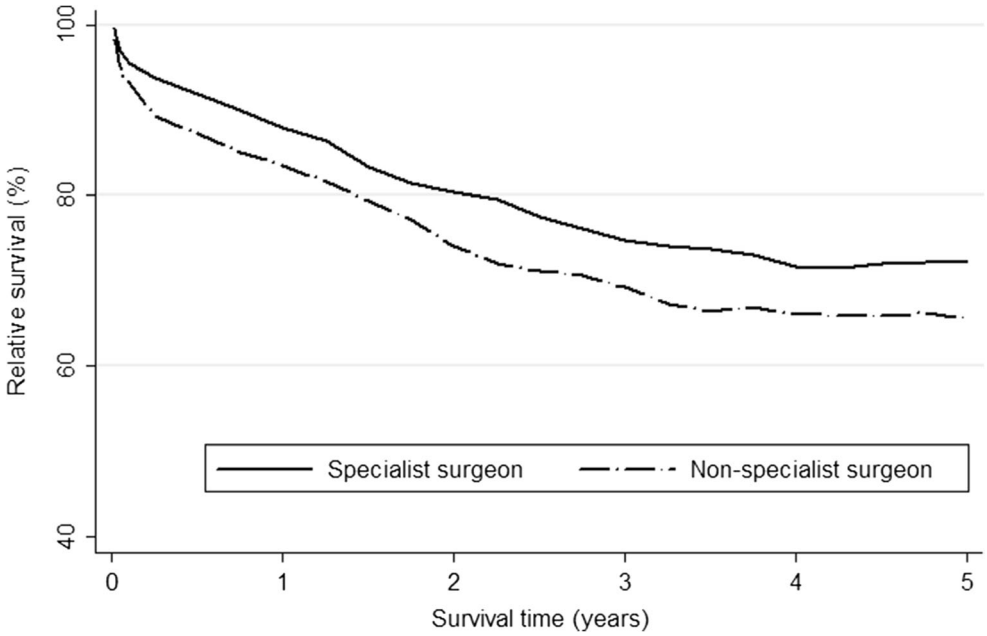

Fig. 1 Five-year relative survival curves after elective surgery for colon cancer by specialty of surgeon, 2001–2004. P=0.012 (log-rank test)

independently associated with poorer 5-year relative survival. Hospital case volume was not associated with 5-year relative survival.

A conditional 5-year relative survival analysis was subsequently performed, which excluded those who died within 30 days of surgery. After adjustment, no difference in 5-year relative survival between specialist and non-specialist surgeons was found (adjusted RER 1.08 (95 % CI 0.86–1.37); P=0.505). This suggests that higher levels of post-operative mortality led to the observed poorer long-term survival among patients treated by non-specialist surgeons rather than ongoing survival differentials.

Discussion

The results of the present study from a mature cohort show that short- and long-term survival after elective surgery for colon cancer was higher in those treated by specialist colorectal surgeons compared to those treated by non-specialist general surgeons. The relationship between improved outcomes and specialist surgery remained after adjustment for other factors associated with survival. The findings suggest that differences in long-term survival between surgeon groups were driven by higher rates of post-operative mortality observed among those treated by non-specialists. There was no apparent association between hospital case volume and outcomes following elective surgery for colon cancer in this series. These results suggest that elective surgery for colon cancer should be performed under the care of a specialist colorectal surgeon where possible.

The reasons for the observed early survival benefit among those treated by a specialist are less clear. Results from this study show that there was a significant trend towards higher lymph node yields among patients treated with curative intent by a specialist surgeon compared to a non-specialist. This could suggest a difference in operative technique, with non-specialists performing less radical mesocolic excision or central vascular ligation. However, this potential difference in technique is unlikely to affect short-term outcomes and does not appear to have had a significant influence on long-term survival, as no difference between surgeon groups was observed after exclusion of post-operative deaths. The lack of difference in anastomotic leak rates also suggests a similar level of surgical quality performed between surgeon groups. However, a lower lymph node yield among non-specialists could have caused some patients to be under-staged leading to stage migration and differences in long-term outcome.

The finding that specialist surgeons performed almost three times the number of elective colon cancer operations than non-specialists also supports a body of evidence suggesting a volume-outcome relationship with colon cancer outcomes [3]. While the absolute number of elective colon cancer resections per surgeon per annum appears low in this cohort, it is of note that the majority of specialist colorectal surgeons from the UK also perform a significant volume of surgery for rectal cancer and benign colorectal disease in addition to participation in emergency surgery cover. In addition, the Association of Coloproctology of Great Britain and Ireland suggests that surgeons who perform elective colorectal cancer surgery should carry out at least 20 resections per annum (approximately 13 colonic resections per annum) [14]. However, these recommendations were introduced on a background of little

evidence to suggest an optimum number of minimum of annual cases per surgeon. Therefore, there is a clear requirement for further research to explore other ways of assessing surgical training and competence to perform colon cancer surgery to the optimum quality.

Higher volume surgeons often have greater clinical experience leading to improved clinical decision making, case selection and honed surgical technique [15]. Another benefit of increased specialisation is that surgeons benefit through a concentrated workload in addition to specialist training and experience [16]. A recent Cochrane Collaboration review found that patients with colon cancer treated by higher volume surgeons had improved overall survival at 5 years but failed to show a significant difference in post-operative mortality [3]. A further recent study from England also failed to demonstrate a significant relationship between post-operative mortality and surgeon or hospital case volume [17]. This suggests that higher surgeon case volume among specialist surgeons was not sufficient to explain the better short- and long-term outcomes observed in the present study. Other non-surgical factors are likely to vary between specialists and non-specialist surgeons. These include, but are not limited to, availability of good quality intensity care and high dependency level post-operative care, enhanced recovery programme use, involvement of specialist colorectal nurses, local access to specialist medical and anaesthetic cover and support from surgical trainees with a specialist interest in colorectal surgery. The influence of these factors on post-operative mortality was unable to be adjusted for in the present study, and further research is required to determine their contribution to the success of the specialist.

In addition to higher case volumes, specialist surgeons were found to be more likely to work in higher volume hospitals. Previous data from the USA suggested that high volume hospitals were associated with improved outcomes following colon cancer surgery [18–20]. However, in this study, hospital volume was not associated with outcome following elective colon cancer surgery, confirming a finding previously described by other groups from the UK [3, 17]. These findings therefore do not provide evidence to support the view that service provision for elective colon cancer surgery should be centralised in larger volume surgical units. Further research is required to ascertain the exact determinants of care that contribute to the observed survival improvement when colon cancer surgery is performed by specialist surgeons.

A particular strength of this study was that it was based on a mature prospectively maintained regional clinical audit database reflecting a wide range of surgical practice from within a defined geographical location. The use of relative survival to assess long-term outcomes also allowed for variations in background mortality rates and life expectancy over time to be adjusted. Relative survival analyses are regarded as the gold standard for assessing long-term outcomes in patients with cancer in large population or registry-based cohorts [21].

The observed difference in early post-operative mortality between surgeon groups is likely to have been determined by differences in post-operative complication rates or other patient- or treatment-related variables. Therefore, one of the main limitations of the present study was the lack of detailed clinicopathological data such as measures of co-morbidity, body mass index, smoking status, biochemical or haematological markers, detailed post-operative complications or information regarding adjuvant chemotherapy. However, limited adjustment for co-morbidity was incorporated in the relative survival analysis as socioeconomic deprivation represents a proxy measure of co-morbidity [12, 22, 23]. An additional limitation of this paper was that the time period under study may not represent current colon cancer surgical practice in the UK. Further contemporary research is therefore required to examine the ongoing influence of non-specialist surgery on colon cancer outcomes.

The lack of an internationally agreed definition of a specialist surgeon also leads to difficulties in comparing the results of this paper to previously published work. The definition of a specialist colorectal surgeon used in the present study, which included membership of a specialist colorectal cancer MDT, access to a dedicated colonoscopy session, a major commitment to the specialty and peer review as a colorectal surgeon, is more robust than other previously published methods using less stringent criteria [4, 11].

This study of a mature prospectively maintained clinical dataset provides further evidence that surgical specialisation, rather than hospital case volume, leads to improved outcomes after elective colon cancer surgery especially in the immediate post-operative period. Onward referral of all confirmed or suspected cases of colon cancer to a specialist colorectal surgeon is likely to lead to further improvements in both short- and long-term outcomes.

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