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Differences according to educational level in the management and survival of colorectal cancer in Sweden

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ABSTRACT

Socioeconomic status (SES) affects survival after a cancer diagnosis. The extent to which differences in management can explain this is not known. Record-linkage between two Swedish Regional Clinical Quality Registers of colorectal cancer and a socio-economic database generated a dataset with information on diagnostic procedures, treatment and survival in patients of different educational background. Three thousand eight hundred and ninety-nine rectal cancer patients from the years 1995 to 2006 and 5715 colon cancer patients from 1997 to 2006 were evaluated. Compared to patients with high education, those with shorter education had poorer relative and overall survival (57.9% 5-year relative survival versus 63.8% in colon cancer, 58.7% versus 69.1% in rectal cancer). There were also differences in diagnostic activity with preoperative computer tomography (40% versus 47.3%) and colonoscopy (56.3% versus 62.8%) being more frequent in highly educated groups ($p = 0.001$ and 0.037, respectively). Surgery resulting in colostomy was performed in 26.9% of rectal cancer patients of high education compared to 35.5% of those with low education ($p = 0.005$). Although rectal cancer has poorer prognosis than colon cancer, it was noted that among the highly educated, rectal cancer patients had better survival than colon cancer patients (69.1% versus 63.8% 5-year relative survival). It thus appears that improved rectal cancer management has benefited mainly patients of middle and higher educational levels. We conclude that socioeconomic differences exist in diagnostic activity and management of colorectal cancer, which may affect survival.

1. Introduction

Studies conducted in a variety of settings have shown that cancer survival is better in individuals with high compared to low socioeconomic status (SES).[1–3] Possible explanations for these gradients include differences in comorbidity burden, life style and health awareness. In some studies marital status and patient's partner's level of education has influenced choice of, and adherence to, treatment.[4,5] Other investigators have reported associations between ethnic background and management and survival.[6] Also, variations in health care seeking behaviour and timing and stage at diagnosis may play a role.[7–9] To date, only few studies have explored possible socioeconomic differences in the management of cancer patients.[10–14]

While some research groups have not found socioeconomic variations in patterns of care and survival,[15,16] others have found differences also in countries with National Health

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Table 1 – Patient characteristics.

	Colon cancer						Rectal cancer					
	Education level				Total	P-value[†]	Education level				Total	P-value[†]
	Low N = 2255	Middle N = 2182	High N = 1254	Missing N = 24	N = 5715		Low N = 1641	Middle N = 1460	High N = 775	Missing N = 23	N = 3899	
Gender (%)						0.688						0.631
Male	1172 (52.0)	1136 (52.1)	635 (50.6)	13 (54.2)	2956 (51.7)		989 (60.3)	865 (59.2)	475 (61.3)	17 (73.9)	2346 (60.2)	
Female	083 (48.0)	1046 (47.9)	619 (49.4)	11 (45.8)	2759 (48.3)		652 (39.7)	595 (40.8)	300 (38.7)	6 (26.1)	1553 (39.8)	
Age						<0.001						<0.001
Median (range)	68 (15–74)	64 (18–74)	62 (22–74)	68 (11–74)	65 (11–74)		67 (27–74)	63 (24–74)	62 (27–74)	67 (45–74)	65 (24–74)	
Mean (sd)	66.0 (7.3)	62.1 (9.7)	61.0 (9.6)	61.5 (17.4)	63.4 (9.1)		65.6 (7.1)	61.8 (9.1)	60.5 (9.1)	65.7 (8.6)	63.2 (8.6)	
Age (%)						<0.001						<0.001
0–54	168 (7.5)	413 (18.9)	296 (23.6)	4 (16.7)	881 (15.4)		135 (8.2)	297 (20.3)	185 (23.9)	3 (13.0)	620 (15.9)	
55–64	596 (26.4)	706 (32.4)	420 (33.5)	6 (25.0)	1728 (30.2)		458 (27.9)	500 (34.2)	288 (37.2)	5 (21.7)	1251 (32.1)	
65–74	1491 (66.1)	1063 (48.7)	538 (42.9)	14 (58.3)	3106 (54.3)		1048 (63.9)	663 (45.4)	302 (39.0)	15 (65.2)	2028 (52.0)	
Stage (%)						0.324						0.025
I	247 (11.0)	224 (10.3)	152 (12.1)	4 (16.7)	627 (11.0)		328 (20.0)	332 (22.7)	207 (26.7)	1 (4.3)	868 (22.3)	
II	784 (34.8)	751 (34.4)	400 (31.9)	6 (25.0)	1941 (34.0)		443 (27.0)	372 (25.5)	179 (23.1)	10 (43.5)	1004 (25.8)	
III	645 (28.6)	615 (28.2)	368 (29.3)	9 (37.5)	1637 (28.6)		452 (27.5)	422 (28.9)	210 (27.1)	3 (13.0)	1087 (27.9)	
IV	531 (23.5)	556 (25.5)	304 (24.2)	5 (20.8)	1396 (24.4)		336 (20.5)	273 (18.7)	143 (18.5)	6 (26.1)	758 (19.4)	
Missing	48 (2.1)	36 (1.6)	30 (2.4)	0 (0.0)	114 (2.0)		82 (5.0)	61 (4.2)	36 (4.6)	3 (13.0)	182 (4.7)	
Distance from anal verge (%)												0.032[a]
0–5 cm							513 (31.3)	441 (30.2)	219 (28.3)	12 (52.2)	1185 (30.4)	
5.01–10 cm							656 (40.0)	566 (38.8)	285 (36.8)	5 (21.7)	1512 (38.8)	
10.01–15 cm							444 (27.1)	428 (29.3)	260 (33.5)	6 (26.1)	1138 (29.2)	
>15 cm							4 (0.2)	4 (0.3)	2 (0.3)	0 (0.0)	10 (0.3)	
Missing							24 (1.5)	21 (1.4)	9 (1.2)	0 (0.0)	54 (1.4)	

[†] P-value for the hypothesis of no difference between the three education groups.
[a] Comparison when excluding >15 cm and missing.

Care systems.[1,2,11,17] Sweden has a tax-financed National Health Care system aiming to provide care to all residents at nominal cost regardless of place of residence or social standing. In the field of cancer care, Regional Oncological Centres were established in the 1980s to develop cancer specific management guidelines to ensure equal access to state of the art treatment. Using information available in population-based Regional Clinical Quality Registers, the aim of the present study was to assess possible associations between socioeconomic factors and the surgical and oncological management of patients with colorectal cancer.

2. Material and methods

The present study was based on a dataset generated by a record linkage between Clinical Quality Registers on rectal- and colon cancer in the Stockholm–Gotland and Uppsala–Örebro regions in central Sweden, a social database (LISA) and the Migration Register. In Sweden all residents are assigned an individually unique national registration number (NRN) that facilitates record linkage between databases. The total population in the two regions included in the present study is almost 4 million (or more than 40% of the Swedish population).

2.1. *Regional Clinical Quality Registers on colorectal cancer*

In both the Stockholm–Gotland and the Uppsala–Örebro regions, Clinical Quality Registers have been established to monitor the quality of management of cancer patients. The Stockholm–Gotland register has almost 100% completeness of rectal cancer patients since 1995 and colon cancer patients since 1996. Patients with rectal cancer in the Uppsala–Örebro region have been registered since 1995 and patients with colon cancer since 1997. The completeness is 98% and 100%, respectively. The Quality Registers are matched with the Swedish Cancer Register and updated continuously. Information on diagnostic procedures is only available in the Uppsala–Örebro-register and thus the cohorts presented in Table 2 are smaller than in other tables.

Table 2 – Diagnostic investigations (only patients in the Uppsala–Örebro region included).

	Education level				Total	*P*-value[†]
	Low N = 1516	Middle N = 1220	High N = 564	Missing N = 11	N = 3311	
Colon cancer						
MRT/CT (%)						0.001
Yes	607 (40.0)	573 (47.0)	267 (47.3)	4 (36.4)	1451 (43.8)	
No	897 (59.2)	633 (51.9)	292 (51.8)	7 (63.6)	1829 (55.2)	
Missing	12 (0.8)	14 (1.1)	5 (0.9)	0 (0.0)	31 (0.9)	
Colon X-ray (%)						0.044
Yes	625 (41.2)	494 (40.5)	192 (34.0)	5 (45.5)	1316 (39.7)	
No	883 (58.2)	717 (58.8)	368 (65.2)	6 (54.5)	1974 (59.6)	
Missing	8 (0.5)	9 (0.7)	4 (0.7)	0 (0.0)	21 (0.6)	
Colonoscopy (%)						0.037
Yes	853 (56.3)	707 (58.0)	354 (62.8)	6 (54.5)	1920 (58.0)	
No	656 (43.3)	501 (41.1)	206 (36.5)	5 (45.5)	1368 (41.3)	
Missing	7 (0.5)	12 (1.0)	4 (0.7)	0 (0.0)	23 (0.7)	
	N = 1065	N = 813	N = 326	N = 7	N = 2211	
Rectal cancer						
MRT/CT (%)						<0.001
Yes	533 (50.0)	486 (59.8)	190 (58.3)	1 (14.3)	1210 (54.7)	
No	520 (48.8)	321 (39.5)	133 (40.8)	6 (85.7)	980 (44.3)	
Missing	12 (1.1)	6 (0.7)	3 (0.9)	0 (0.0)	21 (0.9)	
Colon X-ray (%)						0.682
Yes	447 (42.0)	329 (40.5)	126 (38.7)	4 (57.1)	906 (41.0)	
No	609 (57.2)	479 (58.9)	196 (60.1)	3 (42.9)	1287 (58.2)	
Missing	9 (0.8)	5 (0.6)	4 (1.2)	0 (0.0)	18 (0.8)	
Colonoscopy (%)						0.657
Yes	486 (45.6)	392 (48.2)	163 (50.0)	2 (28.6)	1043 (47.2)	
No	569 (53.4)	414 (50.9)	160 (49.1)	5 (71.4)	1148 (51.9)	
Missing	10 (0.9)	7 (0.9)	3 (0.9)	0 (0.0)	20 (0.9)	
Rectoscopy (%)						0.763
Yes	1047 (98.3)	798 (98.2)	322 (98.8)	7 (100.0)	2174 (98.3)	
No/Missing	18 (1.7)	15 (1.8)	4 (1.2)	0 (0.0)	37 (1.7)	

† *P*-value for the hypothesis of no difference between the three education groups.

2.2. Social database

The LISA database (longitudinal integrated database on labour market research) contains all individuals over the age of 16 registered as residents of Sweden. It is continuously updated and includes information on occupation, highest attained education, annual income, sick leave, welfare dependency (where applicable) and employment status.

2.3. Statistical methods

Differences in characteristics between the three education groups were tested using the χ^2-test and Kruskal–Wallis test. All statistical tests were two-sided.

Estimates of overall survival were calculated using the Kaplan–Meier method. Cox proportional hazard models were used to assess differences in survival between education groups when adjusting for relevant factors and stratifying by stage. Model estimates are presented as hazard ratios with 95% confidence intervals, with the lowest education group being used as reference.

Relative survival was calculated as the ratio of the observed survival in the study population to the expected survival of the background population. The expected mortality rates were assessed from gender-, age- and period-specific life tables for Sweden. The excess mortality rate, i.e. the difference between the observed number of deaths and the expected number of deaths per person-year, was modelled in a Poisson regression model.[18] Model estimates are presented as excess hazard ratios with 95% confidence intervals, with the lowest education group being used as reference. The fit of the Poisson models was verified by residual analysis, and by evaluating the deviance of the models, along with the corresponding degrees of freedom, in a χ^2-distribution.

Relative survival analysis was performed with the statistical software package Stata, using the procedure strs, and further analyses were performed with the R statistical software package.

2.4. SES parameters

Several parameters have previously been used as indicators of social status. These include level of education, income, household income, mean income in area of habitation, house or car ownership etc. Data available in the LISA database provided information on family structure, employment status, income and socioeconomic index. For the purpose of the present study we chose the highest attained level of education as the main indicator of social standing since it is likely to reflect dimensions of health awareness and ability to access and navigate the health care system. The education variable also had the least missing information.

Thirteen thousand and four individuals with a colon cancer diagnosis between 1997 and 2006 and 7729, with a rectal cancer diagnosis between 1995 and 2006 were identified. Patients aged 75 and older at the time of diagnosis were excluded since information on attained education level and occupation was less complete in the oldest age group. We also excluded the heterogeneous group of patients not born in Sweden. One colon cancer patient was lost to follow-up. This way, 5715 colon cancer and 3899 rectal cancer patients remained and constituted our two cohorts (Fig. 1).

3. Results

3.1. Patient characteristics

Patients were categorised according to the highest attained level of education, into 'low' (1–9 years of mandatory school),

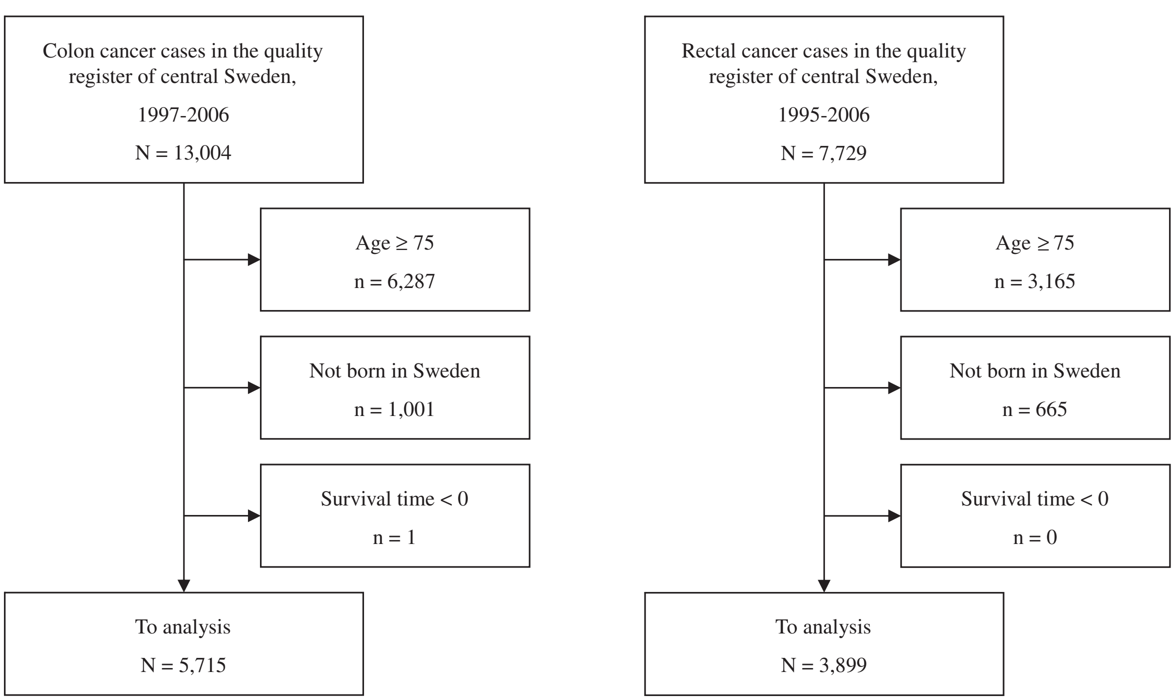

Fig. 1 – Patient selection.

'middle' (10–12 years or high school), and 'high' (university studies or the equivalent). While there was no clear difference in the distribution of tumour stage by education, there was a clear difference by age at diagnosis. Both colon and rectal cancer patients with middle or high education level were significantly younger, with a difference in mean age at diagnosis of about 5 years (Table 1).Because the age difference in itself might influence diagnostic intensity and treatment, adjustment for age was done and this did not alter results.

3.2. *Mode of diagnosis and diagnostic intensity*

Colonoscopy was more often performed in patients with high education, whereas barium enemas were proportionally more common in patients with middle and low education (Table 2). In patients with rectal cancer there were no clear differences in mode of diagnosis apart from a tendency to do more abdominal CT:s (computer tomography) and pelvic MRI:s (magnetic resonance imaging) in patients with middle and high education.

3.3. *Treatment and postoperative morbidity and mortality*

For colon cancer patients elective surgery was slightly more common among the highly educated (Table 3a). No clear differences in the type of surgery were observed. Postoperative complications tended to be less common in the highly educated group. Postoperative 30-day mortality was very low with no clear differences between educational groups. Adjuvant chemotherapy after surgery was more commonly offered to patients with high SES. Preoperative radiotherapy was given less often to patients with lower education (Table 3b). For rectal cancer patients an anterior resection was more frequent in individuals with high compared to low education. Surgery resulting in colostomy was performed in 35.5% of rectal cancer patients of low educational level but only in 26.9% of the highly educated ($p = 0.005$). Similar to the situation in colon cancer, postoperative complications were somewhat more infrequent in patients with high education. There was also no clear difference in postoperative mortality between educational groups, although it was numerically the lowest in patients with high education.

Table 3a – Surgical treatment (only patients in stages I–III undergoing bowel resection included).

	Education level				Total	P-value†
	Low N = 1671	Middle N = 1589	High N = 918	Missing N = 19	N = 4197	
Colon cancer						
Elective/acute surgery (%)						0.153
Elective	1341 (80.3)	1278 (80.4)	766 (83.4)	13 (68.4)	3398 (81.0)	
Acute	326 (19.5)	306 (19.3)	152 (16.6)	5 (26.3)	789 (18.8)	
Missing	4 (0.2)	5 (0.3)	0 (0.0)	1 (5.3)	10 (0.2)	
Type of surgery (%)						0.098
Right-sided hemicolectomy	737 (44.1)	673 (42.4)	365 (39.8)	10 (52.6)	1785 (42.5)	
Transverse colon resection	48 (2.9)	44 (2.8)	30 (3.3)	0 (0.0)	122 (2.9)	
Left-sided hemicolectomy	157 (9.4)	183 (11.5)	101 (11.0)	2 (10.5)	443 (10.6)	
Sigmoid resection	381 (22.8)	381 (24.0)	237 (25.8)	3 (15.8)	1002 (23.9)	
Total colectomy	74 (4.4)	58 (3.7)	45 (4.9)	1 (5.3)	178 (4.2)	
Anterior resection	81 (4.8)	89 (5.6)	64 (7.0)	2 (10.5)	236 (5.6)	
Hartmann	30 (1.8)	26 (1.6)	10 (1.1)	1 (5.3)	67 (1.6)	
Other procedure	161 (9.6)	133 (8.4)	66 (7.2)	0 (0.0)	360 (8.6)	
Missing	2 (0.1)	2 (0.1)	0 (0.0)	0 (0.0)	4 (0.1)	
Surgical complications (%)						0.443
	222 (13.3)	200 (12.6)	106 (11.5)	4 (21.1)	532 (12.7)	
Cardiovascular complications (%)						0.377
	54 (3.2)	49 (3.1)	21 (2.3)	1 (5.3)	125 (3.0)	
Infectious complications (%)						0.037
	71 (4.2)	81 (5.1)	27 (2.9)	1 (5.3)	180 (4.3)	
Other complications (%)						0.358
	71 (4.2)	58 (3.7)	29 (3.2)	1 (5.3)	159 (3.8)	
30-Day mortality (%)						0.148
	26 (1.6)	16 (1.0)	7 (0.8)	0 (0.0)	49 (1.2)	
Postoperative chemotherapy in stage III (%)						<0.001
Yes	450 (69.8)	485 (78.9)	292 (79.3)	4 (44.4)	1231 (75.2)	
No	172 (26.7)	101 (16.4)	48 (13.0)	4 (44.4)	325 (19.9)	
Missing	23 (3.6)	29 (4.7)	28 (7.6)	1 (11.1)	81 (4.9)	

† P-value for the hypothesis of no difference between the three education groups.

Table 3b – Surgical treatment (only patients in stage I-III undergoing surgery included).

	Education level				Total	P-value[†]
	Low N = 1221	Middle N = 1123	High N = 595	Missing N = 14	N = 2953	
Rectal cancer						
Preoperative RT (%)						0.048[a]
Yes	919 (75.3)	888 (79.1)	472 (79.3)	10 (71.4)	2289 (77.5)	
No	301 (24.7)	235 (20.9)	123 (20.7)	4 (28.6)	663 (22.5)	
Missing	1 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.0)	
Type of surgery (%)						0.005
Not resected	1 (0.1)	1 (0.1)	1 (0.2)	0 (0.0)	3 (0.1)	
Anterior resection	736 (60.3)	715 (63.7)	409 (68.7)	7 (50.0)	1867 (63.2)	
Rectal amp. + Hartmann	433 (35.5)	377 (33.6)	160 (26.9)	7 (50.0)	977 (33.1)	
Local excision	35 (2.9)	25 (2.2)	23 (3.9)	0 (0.0)	83 (2.8)	
Other procedure	13 (1.1)	4 (0.4)	2 (0.3)	0 (0.0)	19 (0.6)	
Missing	3 (0.2)	1 (0.1)	0 (0.0)	0 (0.0)	4 (0.1)	
Surgical complications (%)						0.081
	310 (25.4)	262 (23.3)	123 (20.7)	6 (42.9)	701 (23.7)	
Cardiovascular complications (%)						0.074
	52 (4.3)	32 (2.8)	15 (2.5)	0 (0.0)	99 (3.4)	
Infectious complications (%)						0.335
	107 (8.8)	81 (7.2)	44 (7.4)	0 (0.0)	232 (7.9)	
Other complications (%)						0.398
	58 (4.8)	63 (5.6)	25 (4.2)	0 (0.0)	146 (4.9)	
30-Day mortality (%)						0.589
	15 (1.2)	9 (0.8)	6 (1.0)	0 (0.0)	30 (1.0)	

† *P*-value for the hypothesis of no difference between the three education groups.
a Comparison after exclusion of the one patient with missing information.

3.4. *Survival*

A clear pattern of better survival, crude and relative, for more highly educated groups was observed (Table 4). This was seen in both colon and rectal cancer in all stages combined, in stages I + II and stage III separately, but not in stage IV. In more detailed analyses on the available socioeconomic data, better survival was observed among divorced or married compared to single or widowed patients. Analysis by employment status showed the most favourable outcomes for employed individuals and students, compared to unemployed and patients with disability pension although these latter groups were small. When using the Poisson model to correct for factors such as sex, age, elective or emergency surgery, type of hospital and, in the case of rectal cancer, preoperative radiotherapy, the gradients in survival stratified by educational level were unaffected (above data not shown).

4. Discussion

The results of the present study show that there are social gradients in the management of colorectal cancer. We observed differences not only in staging and surgical approach, but also with regard to oncological adjuvant treatment. Also, compared to patients with low education, patients with high education had less surgical complications and better survival in stages I, II and III of both colon and rectal cancer but not in stage IV. The difference in both OS and RS between patients with high versus low education was comparatively large (HRs about 0.7 in the regression analyses). The differences are of the same magnitude as those achieved by adjuvant chemotherapy in colon cancer and larger than those seen after preoperative (chemo) radiotherapy in rectal cancer.

Based on results from several earlier studies[2,3] it is well established that survival, both overall and cancer-specific, is poorer in patients with low SES. Social gradients in cancer management have previously been reported in settings where private health care is an option, or in countries where ethnic factors appear to play a role in accessing high quality health care.[19]

Five-year survival has for decades been slightly higher in colon cancer compared to rectal cancer patients. However, in the 1990s it was observed for the first time that 5-year survival was superior in rectal cancer patients managed in the Uppsala region.[20] The most plausible reasons for this shift were systematic efforts to improve staging and treatment in rectal cancer patients, first in the county of Uppsala and then nationwide.[21] Similar changes in the relation between relative survival of colon and rectal cancer patients have also been reported in other countries that have made efforts to improve the management of rectal cancer, such as Norway and the Netherlands.[22,23] It is, therefore, of note that in this study a better survival in rectal cancer compared to colon cancer was observed in the middle and highly educated groups. This raises questions whether efforts to optimise rectal cancer management predominantly have benefited patients with higher education.

Table 4 – Overall survival (OS) and relative survival (RS) in patients of different educational levels (excluded are patients missing information on education or stage).

	Stage I + II N = 2558			Stage III N = 1628			Stage IV N = 1391			Stage I–IV N = 5577		
Colon cancer												
Overall survival	*n*	5-year OS	HR[a]	*n*	5-year OS	HR[a]	*n*	3-year OS	HR[a]	*n*	5-year OS	HR[a]
Low education	1031	75.3 (72.6–78.1)	ref.	645	52.1 (48.2–56.3)	ref.	531	13.4 (10.7–16.7)	ref.	2207	52.3 (50.2–54.5)	ref.
Middle education	975	81.6 (79.0–84.2)	0.81 (0.66–0.99)	615	55.8 (51.8–60.2)	0.95 (0.80–1.13)	556	15.2 (12.4–18.5)	0.97 (0.85–1.11)	2146	55.2 (53.0–57.4)	0.94 (0.86–1.03)
High education	552	84.7 (81.5–88.0)	0.72 (0.55–0.93)	368	64.6 (59.6–70.1)	0.74 (0.60–0.92)	304	14.3 (10.8–18.9)	0.93 (0.79–1.08)	1224	59.5 (56.7–62.5)	0.84 (0.75–0.94)
Relative survival	*n*	5-year RS	EHR[b]	*n*	5-year RS	EHR[b]	*n*	3-year RS	EHR[b]	*n*	5-year RS	EHR[b]
Low education	1031	83.3 (80.1–86.2)	ref.	645	57.5 (53.0–61.8)	ref.	531	14.3 (11.4–17.6)	ref.	2207	57.9 (55.5–60.2)	ref.
Middle education	975	88.2 (85.3–90.8)	0.73 (0.53–0.99)	615	60.1 (55.6–64.5)	0.95 (0.78–1.15)	556	15.9 (12.9–19.1)	0.97 (0.85–1.11)	2146	59.6 (57.2–61.9)	0.95 (0.85–1.05)
High education	552	90.7 (86.8–93.8)	0.60 (0.39–0.91)	368	69.0 (63.1–74.3)	0.74 (0.58–0.95)	304	15.3 (11.4–19.7)	0.91 (0.78–1.07)	1224	63.8 (60.7–66.8)	0.83 (0.73–0.94)
	N = 1861			N = 1084			N = 752			N = 3697		
Rectal cancer												
Overall survival	*n*	5-year OS	HR[a]	*n*	5-year OS	HR[a]	*n*	3-year OS	HR[a]	*n*	5-year OS	HR[a]
Low education	771	74.1 (70.9–77.4)	ref.	452	50.9 (46.3–56.0)	ref.	336	12.2 (9.1–16.4)	ref.	1559	53.2 (50.7–55.9)	ref.
Middle education	704	80.0 (76.9–83.2)	0.84 (0.67–1.05)	422	58.8 (54.0–64.0)	0.90 (0.73–1.10)	273	17.8 (13.8–23.1)	0.90 (0.75–1.07)	1399	59.8 (57.2–62.5)	0.87 (0.77–0.97)
High education	386	83.9 (80.1–87.9)	0.67 (0.49–0.90)	210	65.6 (59.0–72.9)	0.74 (0.55–0.98)	143	15.1 (10.2–22.5)	0.96 (0.77–1.19)	739	64.3 (60.8–68.0)	0.76 (0.65–0.88)
Relative survival	*n*	5-year RS	EHR[b]	*n*	5-year RS	EHR[b]	*n*	3-year RS	EHR[b]	*n*	5-year RS	EHR[b]
Low education	771	81.7 (77.9–85.1)	ref.	452	56.4 (50.9–61.6)	ref.	336	12.8 (9.3–16.9)	ref.	1559	58.7 (55.8–61.5)	ref.
Middle education	704	86.4 (82.8–89.6)	0.80 (0.57–1.12)	422	63.8 (58.2–68.9)	0.87 (0.68–1.11)	273	18.8 (14.3–23.8)	0.90 (0.75–1.08)	1399	64.7 (61.7–67.5)	0.85 (0.75–0.97)
High education	386	90.0 (85.4–93.8)	0.58 (0.36–0.94)	210	70.8 (62.9–77.6)	0.67 (0.48–0.93)	143	15.7 (10.1–22.4)	0.98 (0.78–1.23)	739	69.1 (65.0–72.8)	0.73 (0.62–0.87)

[a] Hazard ratio according to the Cox proportional hazards model, adjusted for age and gender.
[b] Excess hazard ratios according to the Poisson model, adjusted for age and gender.

Our findings with regard to diagnostic procedures may reflect differences between hospitals from which the cases were recruited. There are two major methods used to diagnose colon cancer; colonoscopy or barium enema. Colonoscopy is more sensitive than barium enema and enables diagnostic biopsy and investigation of the colon and rectum in one session.[24,25] Since it requires trained specialists and is time-consuming its use may be limited to some centres in urban areas, where highly educated individuals tend to favour to reside. For this reason, we examined diagnostic methods with respect to rural and urban hospitals. No evidence was found of higher use of colonoscopy at urban hospitals. In some rural areas, the colonoscopy rate was as high as 80% compared to 55% in the largest university hospital. Thus, place of residence does not appear to explain the observed social gradient in use of colonoscopy.

Since the surgical approach depends partly on the localisation of the tumour, it can be argued that anterior resection was more common in highly educated patients because they had a higher proportion of proximal tumours than patients of low education (33.5% versus 27.1% respectively, $p = 0.032$). In line with our findings, surgery resulting in colostomy has previously been shown to be more common in patients of low SES.[26] Possible explanations may include higher age, a weaker pelvic floor due to less exercise, more manual labour and, in women, more pregnancies than in patients of higher education. It is also possible that patients are not considered for anterior resection based on their SES.

Due to the high completeness of the Regional Clinical Quality Register on colorectal cancer, our cohort included over 99% of the patients with a diagnosis of either colon or rectal cancer in Central Sweden during the period under study. Information on several indicators of socioeconomic standing was retrieved from the LISA register. Data on attained educational level were available for 99.6% of colon cancer patients and for 99.4% of rectal cancer patients. We choose not to present data on other socioeconomic indicators such as income, employment status, marital status and socioeconomic index, but results for these indicators were all in line with those observed for the education variable.

Patients with high education were on average 5 years younger than those with low education, which may reflect that higher education has become more easily available in Sweden in recent decades. A separate analysis showed that the observed disparities in management and survival remained virtually unchanged following consideration of age. According to very recent population statistics from SCB (Statistical Central Bureau), 22% of Swedish citizens in the age bracket 16–74 years have low educational level, 44% have medium and 31% are university educated or the equivalent. Distribution is quite uneven with the over 65s having 34% of low level and only 12% of high, whereas people between 25 and 34 years of age have 12% of low level and 30% of high. For the time period under study and with the age distribution in the cohort, educational level was distributed as in the Swedish population.

Several factors of potential importance were not available in the database at hand. We had no data on lifestyle factors or on comorbidity burden, which are likely to vary by social standing.[27] While results from some studies suggest that the role of comorbidity on prognosis of colorectal cancer is limited,[28] others have found evidence of a significant role of concomitant diseases.[29,30] Comorbidity may affect treatment given, and, both indirectly and directly, survival. Also, no information was available on delay from diagnosis to start of treatment, which may also be of importance in explaining differences in survival.

Relative survival was calculated based on expected survival in the general population. Thus, no information was available on expected survival by educational level.

Palliative treatments are not registered in the Quality Registers. Thus it is not possible to determine to which extent social differences influence treatment after a recurrence. However, we could not detect any gradients in stage IV disease at diagnosis, and most of stage IV patients are offered palliative treatments.

In conclusion, we found evidence of social gradients in colorectal cancer survival and that patients with low education are less likely to receive preoperative radiotherapy, postoperative chemotherapy and different types of surgery. Since it is unlikely that differences in diagnostic intensity and choice of surgical approach represent the only explanations for social gradients in outcome, differences in referral to and provision of adjuvant treatment may be of greater relevance. The observed differences in survival may also reflect aspects of provider–patient interactions in which SES could play a subtle role when choosing appropriate investigations and management. The role of differences in management for social gradients in survival must be further explored.

Conflict of interest statement

None declared.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ejca.2010.12.013.

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