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Colorectal cancer survival in socioeconomic groups in England: Variation is mainly in the short term after diagnosis

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ABSTRACT

The objective of this study was to examine differences in cancer survival between socioeconomic groups in England, with particular attention to survival in the short term of follow-up.
Patients and methods: Individuals diagnosed with colorectal cancer between 1996 and 2004 in England were identified from cancer registry records. Five-year cumulative relative survival and excess death rates were computed.
Results: For colon cancer there was a very high excess death rate in the first month of follow-up, and the excess death rate was highest in the socioeconomically deprived groups. In subsequent periods, excess mortality rates were much lower and there was less socioeconomic variation. The pattern of variation in excess death rates was generally similar in rectal cancer but the socioeconomic difference in death rates persisted several years longer. If the excess death rates in the entire colorectal cancer patient population were the same as those observed in the most affluent socioeconomic quintile, the annual reduction would be 360 deaths in colon cancer and 336 deaths in rectal cancer patients. These deaths occurred almost entirely in the first month and the first year after diagnosis.
Conclusion: Recent developments in the national cancer control agenda have included an increasing emphasis on outcome measures, with short-term cancer survival an operational measure of variation and progress in cancer control. In providing clues to the nature of the survival differences between socioeconomic groups, the results presented here give strong support for this strategy.

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1. Introduction

Colorectal cancer is the third most common cancer in the UK, with more than 37,000 new cases diagnosed annually.[1] In recent years, survival from the disease has increased, and five-year cumulative relative survival is now 54%.[2] Survival estimates are not uniform across the population, and there is clear evidence of lower survival in the more socioeconomically deprived groups.[3,4]

There is indirect evidence to suggest that differences in the extent of disease at diagnosis, treatment and comorbidities account for some of the variation in survival between European countries,[5–7] and more detailed studies of variation between populations and within populations are required to further characterise and understand the differences in cancer survival.

The majority of previous studies have examined cumulative survival differences five years after diagnosis, but if differences in the extent of disease at diagnosis or initial treatment contribute substantially to the observed variations in survival, then differences at earlier time points in the course of the disease may be more revealing.[8] Several recent international comparison studies of colorectal cancer[9–11] and other types of cancer[12,13] have demonstrated that the most important variation in relative survival occurs in the first months and in the first few years after diagnosis. Moreover, these international differences were often strongly age-dependent, with most of the international variation occurring in the oldest patients.[11,12]

The present paper extends this strategy of age-specific and follow-up period-specific comparison to the question of variation in survival between socioeconomic groups in England. The aim of the study is to address whether the socioeconomic variation in colorectal cancer survival in England is especially pronounced in the short term of follow-up after diagnosis. It was hoped that such an understanding could help identify strategies to improve colorectal cancer survival in England and reduce the survival gradient between socioeconomic groups within England.

2. Patients and methods

All cases of invasive colorectal cancer (ICD-10: C18-C20) diagnosed in the period 1996–2004 were extracted from the population-based cancer registries in England. In total 256,500 records were extracted.

Among the 256,500 patients the median age was 71 years for males and 75 years for females. Colon cancer patients were slightly older than rectal cancer patients: 74 and 71 years, respectively. Median ages in the five deprivation quintiles were 72, 73, 73, 74 and 73 years from the most affluent quintile 1 to the most deprived quintile 5.

Table 1 documents the exclusion criteria applied to the dataset prior to analysis. All death-certificate-only (DCO) cancer registrations (9780 cases or 3.8% of the total) were excluded, as were any remaining cases with a recorded survival time of zero days (5679 or 2.2%). This left a study population of 241,041 eligible cases diagnosed in 1996–2004. The principal analysis was a cross-sectional "period analysis" whereby the probabilities of survival were estimated in the recent follow-up period 2001–2004,[14] providing up-to-date estimates of patient survival. Cases were, therefore, only informative if they contributed follow-up during this time period. This reduced the number of informative cases to 181,359 (Table 1).

Deprivation scores were assigned to each colorectal cancer patient using the Income Domain of The Indices of Multiple Deprivation 2007 (IMD2007), released by the Department of Communities and Local Government.[15] The Income Domain is mainly influenced by different forms of social income support. The IMD2007 is based on small geographical areas, Lower Super Output Areas (LSOAs), each of which contains an average population of 1500 people. There are 32,482 LSOAs in England, and these were ranked from most deprived to the most affluent. These were then split into five quintile groups with an equal number of LSOAs in each. The most affluent group was labelled Quintile1 and the most deprived Quintile 5. The postcode of the patient's address at the time of diagnosis was used to find the LSOA of residence and thus their quintile of deprivation.

Relative survival was calculated as the ratio of the observed survival in the study population to its expected survival.[16] The latter was computed on the basis of annual sex- and age-specific life tables for each of the five deprivation quintiles.[17] To describe the differences between the socioeconomic groups we plotted, for each deprivation group, age group, and follow-up interval, the excess death rate per 100 person-years, with the numerator being the difference between the observed number of deaths and the corresponding expected number of deaths based on the deprivation quintile-specific life tables.

The pre-specified analysis strategy was to analyse colon cancer (C18) and rectal cancer (C19–C20) separately, and to combine males and females.

3. Results

Table 2 shows the conventional five-year cumulative relative survival estimates for the five socioeconomic deprivation quintiles, stratified into five age-groups. In the younger patients (0–69 years) survival was higher for rectal cancer than for colon cancer, but in the older patients (70+ years) survival was generally highest for colon cancer.

For both colon cancer and rectal cancer, and for all age groups of patients, there was higher survival in the most affluent group (Quintile 1) compared to the most deprived group (Quintile 5). The differences between these two extreme quintiles were 4–7% points for colon cancer and 6–15% points for rectal cancer.

Figs. 1 and 2 show the estimated excess death rates for patients with colon cancer and rectal cancer, respectively. For each type of cancer, the figure shows excess deaths rates (vertical axes) in relation to socioeconomic quintile (five colour-coded lines), age-group (horizontal axes), and four follow-up intervals (from top left corner [first month of follow-up] to bottom right corner [the last three years of the five-year follow-up period]).

Table 1 – Overview of exclusions from cancer registry data prior to analysis.

	Colon cancer											
	Men						Women					
	Quintile of deprivation					Total	Quintile of deprivation					Total
	Q1	Q2	Q3	Q4	Q5		Q1	Q2	Q3	Q4	Q5	
Diagnosed in 1996–2004	16,346	17,563	16,971	15,916	14,205	81,001	15,492	17,687	17,774	16,469	13,888	81,310
Exclusions												
DCO	624	658	624	592	575	3,073	752	1,024	1,011	888	702	4,377
Zero survival time	304	385	400	411	420	1,920	369	488	555	548	464	2,424
Eligible	15,418	16,520	15,947	14,913	13,210	76,008	14,371	16,175	16,208	15,033	12,722	74,509
Informative[a]	11,948	12,467	11,827	11,097	9,466	56,805	10,991	12,176	12,008	10,797	8,973	54,945
	Rectum cancer											
	Men						Women					
	Quintile of deprivation					Total	Quintile of deprivation					Total
	Q1	Q2	Q3	Q4	Q5		Q1	Q2	Q3	Q4	Q5	
Diagnosed in 1996–2004	10,782	11,866	11,611	11,315	10,869	56,443	6,927	7,964	8,203	7,918	6,734	37,746
Exclusions												
DCO	182	241	219	212	205	1,059	204	277	325	280	185	1,271
Zero survival time	78	128	144	151	143	644	108	147	143	164	129	691
Eligible	10,522	11,497	11,248	10,952	10,521	54,740	6,615	7,540	7,735	7,474	6,420	35,784
Informative[a]	8,532	9,035	8,689	8,239	7,626	42,121	5,236	5,949	5,940	5,641	4,722	27,488

a Patients contributing follow-up time in the period 2001–2004.

Table 2 – Five-year relative survival (%) by age group and quintile of deprivation.

	Age (0–49)	Age (50–59)	Age (60–69)	Age (70–79)	Age (80+)
Colon cancer					
Quintile 1	58.0 (54.5–61.3)	55.7 (53.5–57.9)	56.4 (54.7–58.0)	53.6 (52.0–55.2)	47.4 (44.8–50.0)
Quintile 2	59.5 (55.9–62.9)	56.6 (54.3–58.9)	54.9 (53.2–56.5)	50.7 (49.2—52.3)	44.2 (41.9–46.5)
Quintile 3	58.3 (54.8–61.8)	54.9 (52.5–57.2)	54.2 (52.4–55.9)	51.3 (49.7–52.8)	44.1 (41.8–46.4)
Quintile 4	56.2 (52.5–59.7)	50.7 (48.1–53.2)	53.1 (51.3–55.0)	47.4 (45.8–49.0)	38.5 (36.2–40.8)
Quintile 5	54.4 (50.7–58.0)	51.6 (48.9–54.4)	49.1 (47.1–51.0)	46.9 (45.2–48.7)	42.7 (40.0–45.5)
Rectum cancer					
Quintile 1	62.3 (58.1–66.3)	63.6 (61.0–66.0)	64.8 (62.7–66.8)	53.0 (50.7–55.3)	39.7 (36.3–43.3)
Quintile 2	65.3 (61.1–69.1)	61.2 (58.6–63.8)	61.2 (59.1–63.2)	56.1 (54.0–58.2)	39.9 (36.6–43.2)
Quintile 3	60.5 (56.1–64.6)	58.2 (55.4–60.9)	57.4 (55.3–59.5)	49.9 (47.8–51.9)	38.8 (35.6–42.1)
Quintile 4	53.1 (48.7–57.3)	56.9 (54.0–59.6)	55.8 (53.6–58.0)	46.5 (44.4–48.6)	37.5 (34.3–40.8)
Quintile 5	53.0 (48.5–57.4)	51.0 (48.0–53.9)	49.7 (47.4–51.9)	44.0 (41.8–46.2)	33.5 (30.1–37.0)

For colon cancer (Fig. 1) there was a very high excess death rate in the first month of follow-up, ranging from about 25 excess deaths per 100 person-years in the youngest patients to more than 200 per 100 person-years in the oldest. (Note that it requires the contribution of at least 1200 individual patients, each contributing up to one month, to make up 100 person-years in this one-month stratum.) There was a constant range of variation between the five deprivation quintiles in this first month, with the most deprived group always having the highest excess death rate. The absolute difference between the most and the least deprived groups was not dependent on age, and was around 25–50 excess deaths per 100 person-years.

In the subsequent 11 months of follow-up (taking follow-up to one year), excess mortality rates were much lower than in the first month, with estimates from about 20 per 100 in the youngest patients to around 50 per 100 in the oldest. The socioeconomic groups were much closer in this interval, but the same pattern of variation still remained between the five groups. In the remainder of the period of follow-up (1–2 years and 2–5 years), a small excess death rate persisted, but had little association with age or with deprivation quintile.

For rectal cancer (Fig. 2) the absolute levels of excess mortality were lower than for colon cancer (note the different scale on the vertical axes in Figs. 1 and 2). The pattern of variation in excess death rates was generally similar in rectal cancer and colon cancer, with a highly age-dependent excess mortality in the short term (0–1 month and 1 month to 1 year). However, there was a substantial absolute difference between the five deprivation quintiles at least up to the two-year mark. Thus, the socioeconomic difference in death rates persisted several years longer in rectal cancer than in colon cancer.

We computed a log-linear regression slope parameter expressing the average relative change in death rate per one

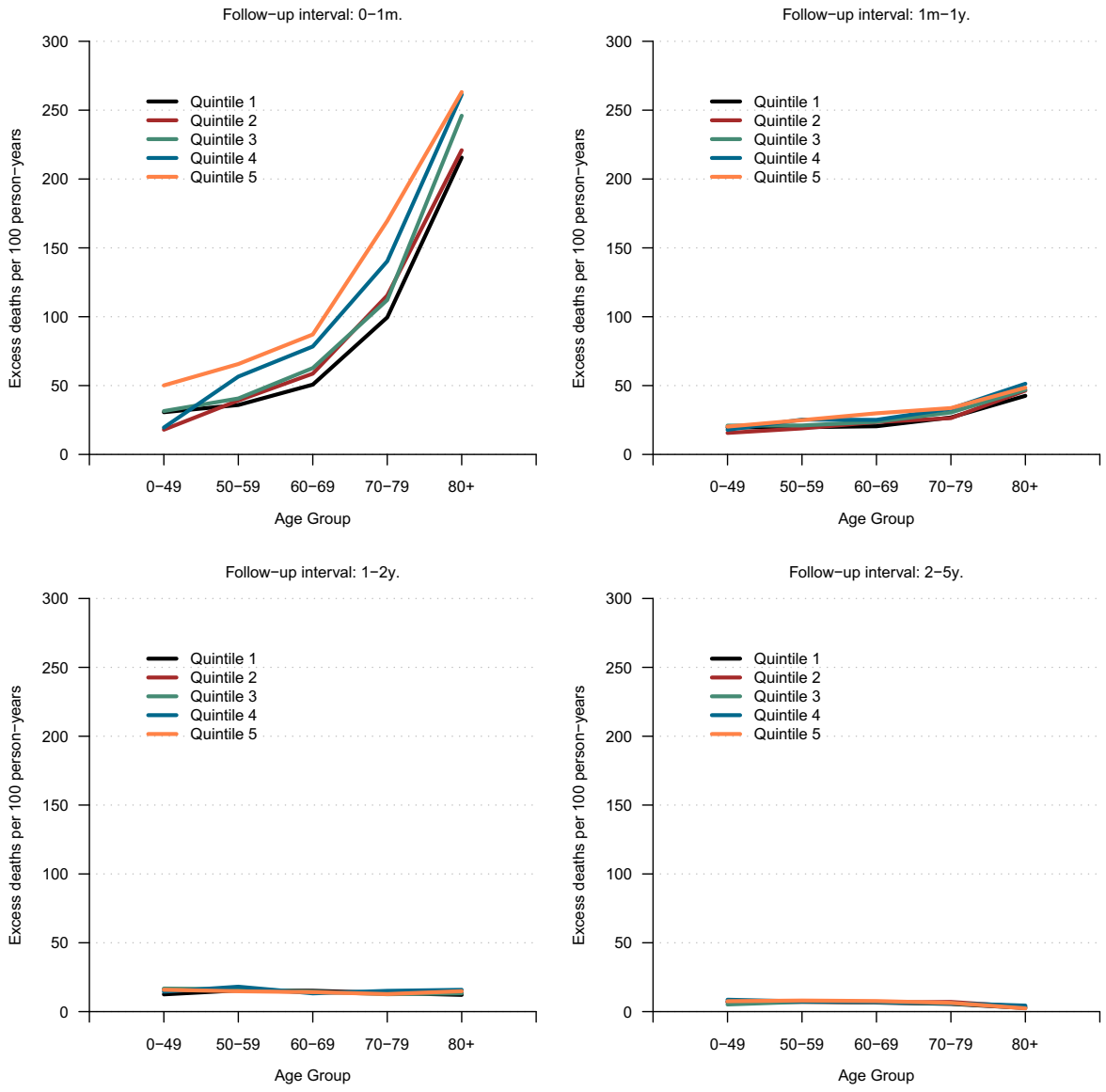

Fig. 1 – Excess death rates among colon cancer patients in socioeconomic quintiles in England 2001–2004, by age at diagnosis and period of follow-up.

quintile increment, separately for each period of follow up. For colon cancer, the four gradients were 1.11 ($p < 0.001$) in the interval 0–1 month, 1.07 ($p < 0.001$) in 1 month to 1 year, 1.01 ($p = 0.51$) in 1–2 years, and 1.02 ($p = 0.16$) in the interval 2–5 years. The corresponding slopes (and p-values) for rectal cancer were 1.12 ($p < 0.001$) in the interval 0–1 month, 1.11 ($p < 0.001$) in 1 month to 1 year, 1.09 ($p < 0.001$) in 1–2 years, and 1.06 ($p < 0.001$) in the interval 2–5 years.

Tables 3 and 4 show the absolute numbers of annual excess deaths, computed in relation to the general population life expectancies (upper part of the tables) and excess deaths in quintiles 2–5 computed relative to the death rates in the most affluent quintile (lower part). The total annual number of excess deaths at five years post diagnosis was 6280 in colon cancer patients and 3707 in rectal cancer patients.

The numbers in the lower parts of the tables can be thought of as 'avoidable' deaths. If we imagine a scenario where the excess death rates in the entire colorectal cancer patient population were the same as those observed in the most affluent socioeconomic quintile, the reduction would be 360 deaths in colon cancer and 336 deaths in rectal cancer patients. These deaths occurred almost entirely in the first month and the first year after diagnosis.

In the follow-up period of 1–2 years and 2–5 years, negative avoidable deaths were calculated (Tables 3 and 4). The avoidable deaths calculation is based on deaths from all causes. Eventually all will die, and the positive early avoided deaths will be counteracted by negative avoidable deaths in later periods of follow-up.

4. Discussion

This analysis of colorectal cancer survival in England provides further evidence that there is a strong and clinically relevant socioeconomic gradient in relative survival, expressed in

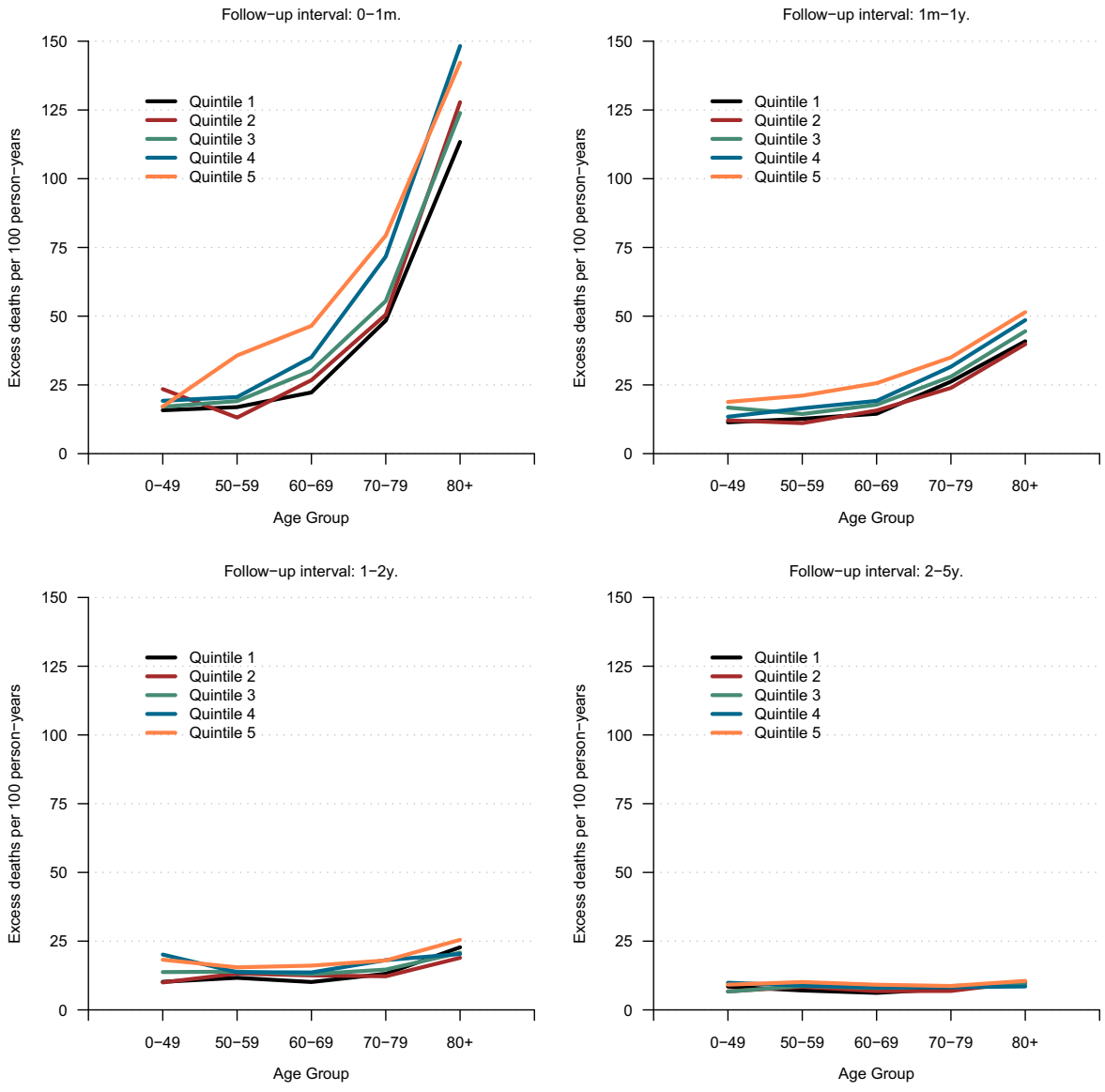

Fig. 2 – Excess death rates among rectal cancer patients in socioeconomic quintiles in England 2001–2004, by age at diagnosis and period of follow-up.

terms of either cumulative five-year survival (Table 2), absolute rates of death (Figs. 1 and 2), or absolute numbers of avoidable deaths (Tables 3 and 4).

The results show that the excess mortality (or survival deficit) in the socioeconomically deprived groups is a short-term phenomenon, most prominent in the first month of follow-up and thereafter largely confined to the first year (colon cancer) or the first two years (rectal cancer) after diagnosis.

In the current study, absolute measures of outcome were used in preference to relative measures, and time-stratified analyses (including attention to very short-term follow-up) were applied in preference to long-term, cumulative measures such as five-year survival proportions.[9–13,18] Several cancer survival comparisons using the same methods have been pursued using data from the cancer registries in England, Norway and Sweden, all of which demonstrated that the differences between the excess death rates among cancer patients in the three countries occurred mainly in the short term.[11–13]

The short-term nature of the mortality and survival differences between regions or patient groups otherwise defined could provide a clue to underlying mechanisms, but a first consideration must be that they may be artefactual and due to differences between the cancer registration processes employed in the different groups. The present study, using the same method of analysis within the English dataset as in the international comparison,[11–13] was partly designed as a means of quality assurance of the international epidemiological analyses. There are known differences between the cancer registry systems in England, Norway and Sweden,[12] and it has been suggested that the lower survival estimates observed in England when compared to some other countries are largely artefactual and attributable to incomplete case ascertainment and erroneous recording of survival time in

Table 3 – Annual excess deaths in colon cancer patients versus expectation based on deprivation-specific life tables (upper part) and annual avoidable deaths in quintiles 2–5 relative to quintile 1 (lower part).

	Colon cancer									
	0–1 month		1 month to 1 year		1–2 years		2–5 years		Total	
Annual excess deaths in colon cancer patients versus expectation based on national life tables										
Quintile 1	281	22.8%	638	51.8%	239	19.4%	74	6.0%	1,232	100.0%
Quintile 2	346	25.4%	718	52.7%	245	18.0%	53	3.9%	1,362	100.0%
Quintile 3	358	27.7%	732	56.6%	210	16.2%	−7	−0.5%	1,293	100.0%
Quintile 4	386	30.4%	723	56.9%	195	15.3%	−33	−2.6%	1,271	100.0%
Quintile 5	345	30.7%	603	53.7%	146	13.0%	28	2.5%	1,122	100.0%
Total	1,716	27.3%	3,414	54.4%	1,035	16.5%	115	1.8%	6,280	100.0%
Annual avoidable deaths in given quintile versus expectation based on colon cancer patients in Quintile 1										
Quintile 2	24		17		−1		11		51	
Quintile 3	43		56		−17		−24		58	
Quintile 4	87		89		−12		−31		133	
Quintile 5	104		78		−31		−33		118	
Total	258		240		−61		−77		360	

Table 4 – Annual excess deaths in rectum cancer patients versus expectation based on deprivation-specific life tables (upper part) and annual avoidable deaths in quintiles 2–5 relative to quintile 1 (lower part).

	Rectum cancer									
	0–1 month		1 month to 1 year		1–2 years		2–5 years		Total	
Annual excess deaths in rectum cancer patients versus expectation based on national life tables										
Quintile 1	76	11.1%	331	48.3%	155	22.6%	124	18.1%	686	100.0%
Quintile 2	97	13.2%	354	48.1%	165	22.4%	120	16.3%	736	100.0%
Quintile 3	101	13.0%	401	51.5%	170	21.9%	106	13.6%	778	100.0%
Quintile 4	117	15.2%	408	53.0%	169	21.9%	76	9.9%	770	100.0%
Quintile 5	109	14.8%	408	55.4%	157	21.3%	63	8.5%	737	100.0%
Total	500	13.5%	1,902	51.3%	816	22.0%	489	13.2%	3,707	100.0%
Annual avoidable deaths in given quintile versus expectation based on rectum cancer patients in Quintile 1										
Quintile 2	8		−14		3		9		6	
Quintile 3	12		36		13		11		72	
Quintile 4	32		59		22		−7		106	
Quintile 5	37		103		26		−14		152	
Total	89		184		64		−1		336	

English cancer registries.[19] However, the registration system is the same for all socioeconomic groups in England, and the consistency of the variation in colorectal cancer survival between countries[11] and within England suggests that the survival differences are in fact real and not due to an artefact in English cancer registration.

The prognostic variable most commonly thought to mediate cancer survival differences between subpopulations is the stage of the cancer at the time of diagnosis.[20,21] However, those studies that have been able to assess the contribution of stage differences to socioeconomic variation have given conflicting results, with some reporting a major role of stage[20,22,23] and others concluding that stage has little or no impact.[24–27] A major weakness of our study is the absence of stage information and until such data become routinely available for English patients, and are deemed to be valid and comparable across subpopulations, the influence of stage on the socio-economic survival gradient in England cannot be fully understood. However, given the observed pattern of large survival differences early in the follow-up, it is highly likely that stage at presentation has a major impact on our findings. Detailed analytical studies at the individual level are required to understand the reasons for late presentation, which may be influenced by both the patient and the health care system.

One aspect of stage of presentation relevant for bowel cancer is the risk of secondary manifestations of advanced disease such as acute abdominal obstruction. The patient may arrive in the hospital through an emergency route with advanced disease, in a deranged metabolic state possibly with significant comorbidity, and die shortly thereafter. Death may be due to the disseminated cancer, comorbidity, or complications of surgery or other treatment modalities. This is a relatively rare occurrence, but one that happens more frequently in the poor than in the rich (as shown in the present article), and happens more often in English than in Norwegian or Swedish patients (as shown in the corresponding paper that

compares England, Norway and Sweden, using identical methods of analysis).[11]

In the present data, 10.5% of colon cancer patients and 5.3% of rectal cancer patients died within one month. The corresponding ranges from the most affluent to the most deprived patients were 8.5–12.5% and 4.1–6.4%. For one year of follow-up, the corresponding figures were 35% (31–38%) for colon cancer and 28% (23–33%) for rectal cancer.

Second to stage, there is also evidence that points to variation in comorbidity as a contributor to the variation in mortality between social groups.[27–31] A complication for the statistical analysis is that the recording of stage and comorbidity information may be incomplete in the rapidly fatal patient, and this information may, therefore, not perform well in a multivariate analysis designed to assess whether a social gradient in short-term survival was attenuated by statistical adjustment for stage and comorbidity variables. Similarly, the rapidly fatal patient will be less likely to undergo elective surgery aiming at cure and, as a result, may not be fully assessed for stage and comorbidity, and consequently have these variables coded as "missing" or "not known". This may be a cause of inconsistency between studies that have attempted to decide whether stage variation was the cause of social variation in survival.[20,22–27]

Thirdly, there are suggestions that there may be a separate contribution at the level of the health care system, whereby different social patient groups are given differential treatments or have different preferences.[28,31–33] For example, in the Swedish colorectal cancer population, several papers have indicated that treatment differs between socioeconomic groups, as well as between the sexes.[34–36] However, it is inherently difficult to disentangle cause and effect in this context because stage and comorbidity are both strong factors in the clinical decision between different treatment options. A recent study from Sweden,[37] using statistical cure models, found that both the proportion cured and the survival time of the uncured were lower in patients from lower socioeconomic groups, suggesting that socioeconomic differences could not be attributed solely to lead time bias.

We found that there is a minority subset of the cancer patient population who present with rapidly fatal disease or who die rapidly from other causes. Such patients are unequally distributed across the different socioeconomic groups in England, being more common in the socially deprived groups. Late presentation at diagnosis is probably the major explanatory factor, which suggests that we should pursue the already ongoing strategy of increasing the awareness of early signs and symptoms of cancer in the entire population and among professionals in primary care.[38,39] Strategies to increase awareness need to address socioeconomic and sociocultural barriers. There is evidence of generally improving cancer survival statistics, but also evidence of a widening of the socioeconomic gap between the rich and the poor.[3,4,40,41]

Recent developments in the national cancer control agenda have included an increasing emphasis on outcome measures, with short-term cancer survival an operational measure of variation and progress in cancer control. In providing clues to survival differences, the results presented here and in the comparisons with Norway and Sweden[11–13] give strong support in favour of continuing in this direction.

Conflict of interest statement

None declared.

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